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CONVERSATIONS

ON THE

ANIMAL ECONOMY.

BY A PHYSICIAN.

IN TWO VOLUMES.

VOL. I.

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TO

THE AUTHOR

OF THE

CONVERSATIONS ON CHEMISTRY.

MY DEAR MADAM,

THE present little work aims at communicating, on a plan similar to that which you have so successfully adopted, some information on the structure and functions of the Animal Body. I cannot flatter myself with having succeeded in removing all the difficulties which attach to a popular consideration of such a subject; much less with having imparted to it any portion of the attraction which you have given to Chemistry, Natural Philosophy, and Political Economy. I have endeavoured, however, to present a general and intelligible

view of some of the principal facts and doctrines of Physiology; and hope it may be of use in giving correct ideas on this branch of Natural Science, in which the best educated, and most able part of society, are often but very little informed.

The admirable work of Archdeacon Paley, and the Lectures which have been delivered at the Royal, and other Institutions in this country, have produced, in the public, an interest relative to the Animal Economy, which I shall be happy if these little volumes may at all tend to promote, or to gratify.

I remain,
With great regard,
My dear Madam,
Your faithful Friend, and
Respectful Servant,

THE AUTHOR.

June 24. 1827.

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of receiving instruction, which you have before been kind enough to afford us. It is delightful to hear of a new set of Conversations. Pray what is the subject of them?

DR. A.

They are neither printed, nor sent to the press; and you will be surprised when I tell you, that in this new object of your attention, I purpose being your instructor myself. What think you of a little professional information?

HARRIET.

Why, papa, it is hardly possible that those who live in the house of a physician should not frequently hear medical subjects talked of; but is it really your intention to give us some instructions about the cure of diseases?

DR. A.

By no means. The cure of diseases is the province of the physician or the surgeon, just as it is that of the clergyman to preach sermons, and of the lawyer to bring actions and plead causes; but I need hardly say, that the studies of religion appertain to all, though the sacred duties of the pulpit and the altar belong to a certain set of men educated for the purpose of exercising them; and Charles will tell you, that though it requires a long series of laborious studies to fit a man for the practice of the law, yet there is much elegant and

useful information in its preliminary branches, and much that it is incumbent on every well-educated English gentleman to know. Just so it is in physic. A very useful share of knowledge may be obtained, as to the structure of the human frame, for example, without a person being led to dabble in the treatment of its diseases; and there is no subject which is better adapted than this, to excite wonder and admiration at the power, wisdom, and beneficence of the great Creator. This, in fact, is the subject which I mean to offer to your attention.

CHARLES.

I am very glad to find that you intend giving us a little information about the structure of the animal frame. I have often wished for it; and, indeed, have had serious intentions of attending a course of anatomy, that I may be better prepared to treat some of the cases which occasionally come under the consideration of the lawyer. But how will you, girls, be able to bear with anatomical descriptions, with accounts of bones, muscles, and joints?

DR. A.

Never fear; I shall not make the subject repulsive. It is only so in its associations; and I trust you will soon learn to contemplate the animal economy, as a centre of wonderful design, and admirable aptitude for the purposes of its creation.

SOPHIA.

Indeed, papa, considering how often physic and anatomy are talked of in public companies, it seems to be somewhat proper that people should know a little of the subject of their conversation, rather than descant on matters of which they are entirely ignorant.

DR. A.

I hope I shall soon be able to show you, that the acquisition of a very useful and agreeable quantity of knowledge, relative to the human frame, can be very readily and pleasantly obtained.

In commencing operations, I shall begin at the surface of the body, and first tell you a little about the external coverings, or INTEGUMENTS, as they are called.

SOPHIA.

What, are there more coverings than the skin? I thought that on breaking the skin you got at once to the flesh.

DR. A.

This is rather a hasty, but not an unusual conclusion; and I must anticipate so far my observations, as to tell you, that what you term flesh, is known by the name of muscle, and is that particular substance which is employed in moving the different parts of the body. It lies under the integuments, which are an outer covering and protection to this, and the various other parts below them.

SOPHIA.

Do you mean, then, that all the fleshy parts of animals are appropriated to moving some part or other of the body?

DR. A.

Certainly. There is no part without its use. All the variety of structure of which, as I shall explain to you, the body consists, is subservient to some important effect in the constitution of the animal; so that, if, like the members in Æsop, any one part were to set up a sort of independence of the rest, or to assume any kind of pre-eminence, it would soon discover the error of its reasoning. The integuments form that substance which covers every part of the surface of the body, which is movable over it in all directions, and can be readily taken hold of, and elevated in a mass, separable from the parts beneath. They constitute what is termed the hide in various animals, and consist of three parts; the *scarf-skin*, a *mucous net-work* below, and the *true skin*, which last forms the greatest part of this external covering.

HARRIET.

Then it appears that the common notion relative to the skin, of its being merely the smooth outer bark of the body, is erroneous.

DR. A.

Completely so; for what is usually known by the name of the skin, is nothing more than a thin, insensible pellicle, called the scarf-skin, or cuticle, which is intended to protect the parts beneath from injury, and to preserve their sensibility.

CHARLES.

In fact, it may be considered as bearing the same relation to the skin, which the rind of a tree does to the bark.

DR. A.

Very much so; and it is capable of being separated under various circumstances. A blister, for example, will, by throwing out a small quantity of fluid from the parts beneath, raise the scarf-skin, and make it apparent. Strong work will harden it, as in the hands of labouring people; and, after many severe complaints, the scarf-skin peels off, just as it does in some animals, as serpents, who cast their skin at certain periods: but in those cases, this does not happen till another scarf-skin is formed below, which serves to throw off the old one; so that the sensible skin is never left unprotected. In cases where scarf-skin has been lost, the parts below have a power of throwing out a material which hardens into this particular substance.

HARRIET.

But you spoke of the scarf-skin being insensible: I do not understand how this can be

the case, when we feel so acutely over all our frame.

DR. A.

We feel through the intervention of the scarf-skin, which is diffused over every part of the body in the closest manner, in order to protect the sensibility of the parts beneath; and even dips, to a certain extent, into the tubes which lead into various internal parts of the body. When it is very hard, or much thickened, the sensibility is diminished, or entirely taken away. If, however, impressions were made directly upon the parts below, the feeling would be too greatly excited, and would amount to pain; as may readily be known when any portion of cuticle happens accidentally to be removed.

CHARLES.

One continually hears of pores in the skin. Are these openings for the purpose of suffering any thing below from escaping?

DR. A.

The scarf-skin has in it numerous minute holes or pores, as they are termed in common language, by means of which certain important effects, as we shall afterwards see, are produced; and through some of which the hair issues.

Some anatomists are, however, disposed to deny the existence of any other openings than such as are destined for the passage of hairs. They con-

sider that the tenuity of texture, and bibulous, or absorbing nature of some parts of the scarf-skin, will allow of perspiration passing through it, and will also admit of its imbibing certain substances from without.

I would observe, however, of this opinion, though an ingenious one, and supported by a late able and excellent professor of the Royal College of Surgeons, that the difficulty of discerning minute holes or pores, is not a decisive argument against their existence, since we cannot discover the open mouths of minute vessels, though assured (as we shall afterwards find) that they possess such open mouths as one of their modes of termination. It may likewise be remarked, that the loss of power which attaches to the cuticle, of transmitting a fluid through it, when raised by a blister, is equally applicable to it in whatever way such transmission takes place; and that, on the hypothesis of bibulous transmission, an union to the parts beneath is equally necessary as in the case of minute pores or holes.

HARRIET.

The colour of the scarf-skin, I presume, varies according to differences in complexion and race?

DR. A.

Very little so; for even the scarf-skin of the negro is but very slightly darker than that of the

white. The seat of colour is, in fact, a very thin layer, not thicker than the cuticle, of a soft substance, which is interposed between the scarf-skin and the cutis, or true skin, and is termed the *rete mucosum*, or *mucous net-work*. In the negro, it is, as may be supposed, of a very dark colour; and the colouring matter is capable of being communicated to water, rendering it turbid, and subsiding in the form of a fine carbonaceous powder.

HARRIET.

Then I suppose the dark colour does not descend deeper?

DR. A.

Not at all: the true skin and the parts below are of the same colour, both in whites and blacks. Oxymuriatic acid will render the rete mucosum yellow in negroes, and immersion in water will take away much of the colour. But in the living body it is soon restored.

SOPHIA.

There must, I suppose, be a great number of different colours, or rather shades of colour, among mankind?

DR. A.

There are five principal varieties of colour in the human species, and all of them dependent on the different shades of this mucous coat:—the first is the EUROPEAN, or white; the second is the

Mongolian, yellow, or olive; the third is the American, red, or copper colour; the fourth is the Ethiopian, or black; the fifth is the Malay, brown, or tawny.

SOPHIA.

The European has certainly a great advantage over other colours of countenance, in the power of communicating expression. One can hardly conceive any change of appearance capable of being produced by emotions of mind in other varieties of complexion.

DR. A.

You are perfectly right; and hence it is said, in Spanish America, as an indication of the contempt which the Europeans bear to the natives, "How can those be trusted who know not how to blush?" In the Mongolian there is, however, when the skin is particularly fine, a slight approximation to change of colour, under powerful emotions of mind.

CHARLES.

Would a similar experiment to that which you mention, relative to the skin of the negro, show a deposit, after infusion in water, in the other darker varieties?

DR. A.

I do not know that the experiment has ever been tried; but, at any rate, the quantity of the colouring material would be much less. In very

fair European skins, it has even been by some considered, but without sufficient evidence, as altogether wanting; for though the colouring matter may vary, and in very white skins be altogether wanting, the organ on which it is deposited seems always to exist.

CHARLES.

The colour of the hair, I suppose, depends on the same cause as that of the skin?

DR. A.

To a certain extent; but the origin of the hair is deeper seated, though it takes a shade in passing through the mucous net-work. There seems, however, to be an actual difference in the colour of the rudiment of the hair, connected generally, but in a way not sufficiently known, with the peculiarities of the skin. Some have indeed imagined, that the colour of the skin is produced, or secreted, as we term it, from the bulbs of the hair, because it has been found, on its being removed by blisters, to re-appear at the pores or openings through which the hairs protrude; and also, because there is less colour on such parts as are without hair, as the soles of the feet, and the palms of the hands, than in other parts of the body where hair exists. There seems, however, to be every reason for imagining, that the secretion of this colouring matter is a property of the true skin

generally; for not only are there occasional anomalies in the colour of the hair, as compared with that of the skin, but the palms of the hands, and soles of the feet, are never without considerable colour; and some parts likewise, which are without hair, are occasionally black, as the inside of the lips.

CHARLES.

I recollect that President Jefferson, in his Notes on Virginia, mentions having seen white negroes: are they without the organ of colour, if one may employ such an expression, or does their peculiarity arise from any particular disease?

DR. A.

It is quite the result of natural conformation, and seems to arise, as you suppose, from a want of the power which produces colour in the body. It occurs among persons of all colours, and constitutes what is termed an albino. It exists, likewise, in some quadrupeds; and whenever it occurs, whether in them or the human species, the hair is exceedingly light coloured, soft, and silky; and there is generally a very remarkable peculiarity in the eye, which I shall more particularly explain to you when we come to that organ. Suffice it to say, that the pupil, instead of being black, is red, from the absence of that colouring matter in the body of the eye which exists in ordinary cir-

cumstances. The eye is preternaturally susceptible to light, is kept generally half shut, and is continually twinkling during the day, being better adapted to seeing in the shade, or in the dusk, than in broad daylight. A female was exhibited in London, some years since, in whom these peculiarities were very strikingly evinced.

HARRIET.

I should be curious, Charles, to know something about the white negroes of whom Mr. Jefferson speaks.

CHARLES.

He mentions seven instances of this peculiarity, of which six were in females, three of whom were sisters. They were all the offspring of negroes: one of these had an albino child, and three others had children which were black.

DR. A.

It sometimes happens that the colouring matter of the skin is wanting in particular places; and hence arises white patches of various dimensions, which, in the negro, make a very extraordinary appearance. There was a curious example of this peculiarity seen in a negro boy, in London, a good many years ago.

The true skin forms, as I have mentioned, the principal part of the integuments, and constitutes the organ of touch.

SOPHIA.

But touch is not equally perfect over the whole body. In order to feel, we employ the fingers; and hence, I suppose, they possess, in a greater degree than other parts, the feeling power.

DR. A.

The power of touch exists in the greatest degree, unquestionably, at the ends of the fingers, in slight elevations of the skin, called papillæ. The immediate organs of sensation are, however, small white threads, called nerves, which are more or less immediately derived from the brain, and these are diffused very plentifully over the ends of the fingers, and particularly the papillæ, which, by this means, are calculated to communicate minute impressions with great accuracy.

HARRIET.

I had no idea that there were actually such things as nerves. One hears of nervous people, weak nerves, and disorders of the nerves; but I always fancied that these were other names for fanciful or overcharged complaints.

DR. A.

And so they often are, in common language; but in speaking of nerves, in a more precise and correct manner, you must consider them as having as much a separate existence as bones or flesh.

Most animals have, independently of the general diffusion of sensibility over the surface, some particular part which possesses the sense of touch in a pre-eminent degree. The nose or snout is a very common organ for this purpose in many animals; and with the elephant, large and unwieldy as it is, the extremity of the trunk is provided with an organ, as small and delicate as the human finger, and capable of taking hold of very small objects, as needles or pins, with great facility.

SOPHIA.

I recollect perfectly a small projection at the end of the trunk of the elephant which we saw at Exeter 'Change, like the extremity of a finger, which seemed to be in continual motion, as if in search of something to take hold of.

DR. A.

This is what I mention; and it acts by doubling upon the nostril. When it has laid hold of any thing, it can at pleasure convey it into its mouth, by the curving of the trunk, which has an extraordinary facility of motion.

The skin is largely supplied with blood-vessels, which, it is sufficient to say at present, are very small hollow tubes, conveying blood for the nourishment of the different parts of the body. It has also other vessels passing through it, some of

which carry off what is intended to be thrown out, others which absorb what is designed to be taken in. It is of a dense, fibrous texture, very extensible, but not admitting, like the scarf-skin, of the supply of any part which may be lost.

HARRIET.

But do you mean to say, that if a portion of skin is cut out, or taken off, it is not again supplied?

DR. A.

The part will heal; and, if the skin is brought together very correctly, the cut portions will unite, so as that hardly any mark will remain: but the mark, scar, or eschar, as it is technically called, is a part without skin, and is therefore more liable to injury than before the accident, because less supported. The small-pox and cow-pox, in the marks which they leave behind them, afford an exemplification of the same thing. There is, in each of these diseases, a slight destruction of the skin, in the pustule or vesicle, which is not filled up or repaired, as you may see in the cow-pox mark in each of your arms.

The skin has a certain elasticity in young and middle life, but it does not contract with the muscles situated below it; and hence it forms various folds, which, in the countenance particularly, give a certain variety of expression. It is connected to the parts below by a sort of net-work,

called cellular membrane, and this being soft and extensible, admits of the easy motion of the skin over the parts below. It becomes more rigid as we advance in life; the adhesion is more firm; and hence the depressions are produced which form wrinkles, particularly in thin people.

CHARLES.

I recollect that in the Conversations on Chemistry there is a description of the mode of producing leather; and an interesting example is given of the process, in the mixture of an infusion of oak bark, which possesses in it the tanning principle, with gelatine or isinglass; the product being a firm yellow matter, insoluble in water. The skin of animals has in it, I presume, a large quantity of this particular substance, gelatine, which enables it to undergo that change.

DR. A.

You are quite right. The tanning principle of the oak bark unites with the jelly, through the whole substance of the skin or hide, and produces the change to which we owe so many important parts of our dress, as well as a great number of our most useful implements.

HARRIET.

Is leather thus formed simply by immersing a skin in a strong impregnation of oak bark?

DR. A.

This is the material part of the process; but then there are several accessory ones which I shall describe to you. In the first place, a hide is thrown for a day or two into water, to free it from any impurities which attach to it. It is then laid upon a half cylinder of stone, called a beam, where it is cleared of any adhering fat or flesh. Afterwards, it is thrown into a pit, containing a mixture of lime and water, where it is kept several days, in order to loosen the hair, which is scraped from it on the beam, by a blunt knife, having a handle at each end. It is then put into what is called the mastering pit, with some putrescent material, generally the dung of hens or pigeons, by means of which the hide becomes softened. After it has been again well scraped on the beam, it becomes fit for conversion into leather.

HARRIET.

What a very troublesome preparatory operation! But, as lime is a very corrosive material, I should have thought that the texture of the leather would be injured by its influence.

DR. A.

So it would, if care were not taken to separate it; but when the hides are very thick, and there would be danger of some of the lime being retained in the skin, which it would render so hard

as to be apt to crack, then the liming is omitted, and the separation of the hair is effected by heaping the skins together for a short time, in order to acquire a certain degree of putrescence. In this case, the final preparation for tanning is effected by immersing them in an acid solution, which seems to open the pores, and to fit the hide for the action of the tan.

HARRIET.

But is the tan able to pierce sufficiently the substance of a thick hide, by merely immersing the latter in a strong infusion of the former? One would imagine that the outside would become hard, before the interior could be sufficiently acted upon.

DR. A.

It certainly would; and therefore the skins are exposed, in the first instance, to very weak infusions of the bruised oak bark, which are gradually made stronger and stronger, to the utmost extent. The process is therefore very tedious; eighteen or twenty months being required for the manufacture of the thickest leather, and three or four months for common calf-skin. There is a considerable accession of weight in the formation of the leather, even after the drying is over. This last is effected by hanging the hide in a drying-house, exposed to a free circulation of air.

SOPHIA.

I suppose there is a general similarity in the skins of all animals, so as that they all admit of a conversion into leather by the proper means.

DR. A.

All of them; and even some of the finer membranes are capable of being converted into leather. Here is a specimen of leather made from a portion of the skin of a man who was executed for murder; and I have seen leather prepared from the most delicate skins of birds.

The process, however, which is employed in the fabrication of leather from thin skins, as those of sheep, lambs, goats, &c. requires more nicety, and is carried on as a distinct business. More previous care is necessary in the preparing them for the conversion into leather; and, instead of oak bark, sumach is often employed for the purpose, which is a gum containing a great deal of the tanning principle. In the white skins, however, *tawing* instead of *tanning* is employed; and this consists in an exposure to a solution of alum and salt in warm water, by which a conversion into leather is effected.

SOPHIA.

Are the different varieties of leather, such as Morocco and Russia, dependent on the nature of the skin, or the process employed in the fabrication?

DR. A.

A little on both, but principally on the latter. The real Morocco is made at Fez and Tetuan, from goat-skins, and is prepared by sal gem, or rock salt alone, and not by salt and alum. It is, of course, coloured subsequently, as is the Morocco of this country, which is made of goat-skin, and tanned by sumach. The Russia leather is generally tanned by the bark of the black willow or the birch; and after being coloured is smeared over with birch tar, which gives it its peculiar and characteristic smell.

In the preparing of leather for the purposes for which it is intended, there are various other processes necessary, of which a very important one, for such leather as is to resist wet, is currying, which consists principally in impregnating the leather, with curriers' (generally fish) oil, which penetrates deeply into its pores. Graining is made by friction with box-wood balls, having parallel grooves on them; and the barred surface of Russia leather, by the pressure of a very heavy steel cylinder wound round with wires.

CHARLES.

Glue, I think, is a species of jelly. Is this procured from the skins of animals?

DR. A.

The skins of animals will furnish it; but so will every other substance (of which there are many)

which contains jelly. It is generally procured by boiling the parings of hides and horns of any kind, the pelts from furriers, the hoofs and ears of horses, oxen, calves, sheep, &c.; and after the jelly obtained by such boiling is purified, it is boiled down, put into frames cut into proper sizes, and hardened by exposure to the air. Isinglass is a finer kind of glue, or a very pure jelly, which is prepared, principally in Russia, from the air-bladder and different parts of the entrails of various fish, particularly the sturgeon, by little more than cleansing, cutting out, and drying.

SOPHIA.

Is hardness of the cuticle, when it occurs in working people or others, owing in any way to a sort of natural tanning which it undergoes after its production?

DR. A.

This is an ingenious hypothesis; but, unfortunately for it, the nature of the skin and cuticle are very dissimilar; the skin principally consisting of gelatine or jelly, the cuticle of albumen, or that particular substance which forms the white of an egg. Now an important distinction of jelly is its great solubility in water, and its forming an insoluble precipitate with infusion of oak bark; while the great characteristic of albumen is its coagulating by heat. The analogy which exists between the nature of scarf-skin and albumen,

and the circumstances which show that the former is a modification of the latter, are evinced by both of them becoming yellow by the action of nitric acid, and having the yellow tinge changed to a purple, by means of ammonia.

The hardness which you speak of is capable of being produced by mere pressure, of which the soles of the feet and palms of the hands afford remarkable examples: for though the scarf-skin is naturally thicker in these than in other parts of the body, yet in neither the feet nor the hands could it sufficiently protect the parts beneath from the effects of great exercise, either in walking or labour, unless for the wise provision of having its thickness, and consequently its power of resisting injuries, increased by use. The immediate cause of this augmentation seems to be a curious power, possessed by the skin itself, of furnishing additional materials for the fabrication of scarf-skin, whenever increased pressure seems to indicate a necessity for such augmentation in the protection required.

HARRIET.

Do the skins of other animals admit the same division as that of man, into epidermis, mucous net-work, and true skin?

DR. A.

Pretty nearly so, but with some modifications, depending on the particular nature of the animal.

Some animals, for example, have an exceedingly thick epidermis or scarf-skin, as the elephant and hippopotamus; and even in the human race, the scarf-skin, in some few cases of disease, assumes a hard, irregular, dark-coloured and scaly character, known by the name of ichthyosis, or fish-skin. Instances have been known of a change of cuticle into a brown, thick, hard, and insensible substance, with projections like porcupine's quills; and this totally independent of disease, in the individual having so singular a peculiarity.

HARRIET.

We must, I think, view the cuticle as an important defence to the skin in all animals.

DR. A.

Certainly; and its nature varies according to the medium which they occupy. Those which live in air have their cuticle dry and horny; fish, on the other hand, have it mucous, viscous, or oily, so as to prevent injury by the action of the water upon it. Some animals, I have already observed, as serpents, cast the cuticle once a year, and this in so perfect a way, as that there is even the rotundity of the eye itself discoverable in the exuviæ.

CHARLES.

The scales of the serpent and fish are, I conclude, composed of thickened cuticle.

DR. A.

They have their origin in the skin, and are covered by a thin cuticle or epidermis; but they are not a part, or modification of cuticle, being of a much firmer and harder material. Insects, whether in the larva state, or in that of the pupa, or of the perfect animal, have a true cuticle; but as this, when once dry and hardened, no longer admits of being stretched, so as to accommodate itself to increase of growth, it is thrown off by the larva, as a sort of sheath or case, as soon as the animal has acquired a certain size. This operation, however, takes place at a defined period for every species; and depends, to a certain degree, on atmospheric temperature. Insects are said to be moulting at this crisis, and they are often many days in preparing themselves for it. It sometimes proves mortal to them. The greater part of silkworms, and of the caterpillars of butterflies, cast off their cuticles seven times; and some insects even ten times before they pass into the state of chrysalis.

SOPHIA.

I am ashamed to be under the necessity of requesting you to give us the meaning of those terms, the precise signification of which is not quite in my recollection.

DR. A.

The perfect insect lays its eggs, which form the

first state of the animal. These produce the worm, grub, caterpillar, or larva; which last term is given, because the animal is supposed, in this state, to be under a sort of larva or mask.

The third state is that of the pupa, which is so called from the resemblance to a swaddled child. Synonymous with this are the terms, nymph, aurelia, and chrysalis.

The fourth and last state is that of the perfect insect, imago, or complete image of its species.

CHARLES.

The skin itself, I suppose, as well as the cuticle, varies in thickness in different animals?

DR. A.

Very much so; and in different parts of the same animal, as the back, where the skin is much thicker than elsewhere. There is a peculiarity in the attachment of the skin of the frog and toad to the body, which does not apply to other animals. It is only adherent at a few points; being in other respects a loose bag, inclosing the body; whereas, in most animals, it is closely adherent to the muscular surface beneath, by means of cellular membrane, as I have already mentioned.

CHARLES.

You stated that the origin of the hair is deeper seated than the mucous network. It must arise, I suppose, from the skin itself; and, indeed, the slight

pain which is produced in drawing a hair out by the roots, evinces its origin to be in a sensible part.

DR. A.

Certainly. The hairs are more or less deeply seated, according to their magnitude; some arising nearly at the surface of the skin; others deep in its substance; while others of a larger size extend even below the skin. Each separate hair has a distinct origin in vascular pulp, which is contained in a capsule or covering, lodged either wholly in the body of the skin, or in part beneath it; and having a horny and insensible stem proceeding from it, which pierces through the outer part of the skin, the mucous network, and the scarf skin. The vascular pulp provides for the continued growth of the hair, which is hollow, and contains a small quantity of this pulp, to which it owes its nourishment, in a sort of cellular structure within it.

SOPHIA.

Is every hair then really a tube?

DR. A.

It is so; and a lens of moderate power will discover the tubular formation in large hairs, such as the whiskers of the cat, hare, or seal. These particular hairs, by the way, have, at their origin, a plentiful supply of nerves, which makes them useful as feelers, or organs of touch. The pulpy

matter extends only to that part of the hair which is in a state of growth; and when the hair is about to be shed, the pulp retires, and leaves the lower part of the stem of the hair, in some animals, converted into a solid pointed mass, easily separable from the part below, and in time pushed up from it. The hog's bristle is an example of this, which is thrown off and supplied by others in succession: but there is this peculiarity in the bristle, that it has two canals in its substance, and is composed of a considerable number of small filaments united together, as may be readily observed in a common brush.

I show you here, from a German work, the sketch of a hair from the eyebrows, magnified to a great extent by the solar microscope; (*a a*) being the body of the hair; (*b b*) the bulb; (*c c c*) little roots, which are attached to the bulb; (*d*) the tube or canal.

SOPHIA.

I always supposed, that when a hair was pulled out, its root was taken away, and it would not grow again; but, it would appear, that in such a case, there is only a separation of the upper part of it?

DR. A.

Certainly. The bulb, or material which forms the hair, is left; and hence, when the hair falls off, under circumstances of particular complaints, it is not irretrievably lost, but grows again as the person recovers strength. Most animals lose their coats at particular seasons, which they do by new hairs springing up, and displacing the old ones. In many nations it is customary to pull out the hair of the beard, particularly, by means of pincers; but this operation requires repetition at certain intervals, as you may now readily infer.

CHARLES.

You mentioned that the colour of the hair was not altogether dependent on the nature of the mucous network, inasmuch as its origin is deeper seated. This seems to be confirmed by the circumstance to which you have alluded, that fair people sometimes have dark hair.

DR. A.

This is certainly the case; and skins of the same shade will often have hair of very different colours and descriptions. In general, however, there is,

notwithstanding some occasional anomalies, a certain connection or relation between the colour of the skin and that of the hair and eyes; and with the varieties of colour by which different nations are distinguished, there are certain peculiarities, not only in the colour of the hair, but in its texture and disposition to curl.

SOPHIA.

How is the change of the colour of hair to grey accounted for?

DR. A.

This seems to depend, not only on the absorption, or removal of colour from the hair itself, but on the cessation of that influence on the body of the hair, by means of which its colour is maintained. It does not, however, appear to be necessarily connected with any diminution of power in the hair itself; for many persons have grey hairs, long before age gives them any claim to that distinction: and such people have generally rather less than more the usual tendency to baldness. The change of hair to grey is an effect which sometimes occurs very speedily. Passions of the mind have an extraordinary influence in producing this change, of which the French revolution is said to have furnished many examples. Bichat, a distinguished French anatomist, relates that he has known five or six cases, in which the hair lost its colour in less than a week; and states, that he was ac-

quainted with one person, in whom the hair became grey in even a single night, in consequence of his hearing some distressing news. Some have imagined, that the speedy removal of the colour of the hair, in such case, is owing to the production of an acid; but this opinion, though supported by the authority of Vauquelin, a very eminent French chemist, does not seem to rest on sufficient grounds. There is, indeed, much obscurity in the subject.

The power on which colour depends is sometimes connected with temperature; for many animals of the Polar regions become white in winter, and recover their proper colour in summer. In this case, however, there is a new crop of hair produced for the winter, which is not only light coloured, but much more close and downy than the summer coat; and connected with the production of the warmer covering, is the singular suspension of the power on which the communication of colour depends.

An injury to a part will sometimes affect the production of the colouring material: as in horses, where the new hair is always grey.

CHARLES.

Do the singular productions of skin, which are possessed by the porcupine and hedgehog, bear an analogy to the hair of other animals?

DR. A.

A considerable one, both in nature and mode of formation.

HARRIET.

The clothing which hair is intended to give to quadrupeds is, I conclude, given by feathers to birds; but is there much similarity in structure and nature between feathers and hairs?

DR. A.

In nature they are very much alike, and there is likewise great similarity in structure. The body of a bird, which has just quitted the egg, is covered with a downy hair, instead of feathers. These hairs arise from one common bulb, which is the rudiment of the future feather. In a few days, a black cylinder appears, which opens at its extremity, and gives passage to the feather, while the hairs gradually separate. The growth of the feather is supplied by a pulp in its barrel, which is furnished by blood-vessels entering from below; and when the growth is completed, this pulp dries up, and exhibits the well-known shrivelled substance which is found in the barrels of quills. The immediate interruption which takes place to the growth of feathers, seems to be owing to the formation of new ones, which shoot up, and obstruct the supply of blood to those which have come to maturity, and which are therefore, in the course of time, thrown off. This process is called

moulting; but in order to lose nothing by the spontaneous separation of the feathers, the period is generally anticipated, in those birds whose feathers are in demand, by plucking them before the time that they would actually drop off.

HARRIET.

There must, I suppose, be a good deal of difference in the nature of the feathers of land and water birds.

DR. A.

There seems to be a sort of oily secretion furnished to those of the latter, which prevents them being soaked by wet, in the way that the former would be. This property, I have no doubt, gives them likewise a certain buoyancy, which is useful to them in swimming.

The coverings with which nature has furnished animals are, therefore, in every way accommodated to their particular habits or necessities. But their utility does not terminate with the animal for whose service they are immediately intended. They are of daily importance to man in various ways. We owe to them many of our most valuable articles of clothing; the softness and warmth of our beds and couches; and the materials of numerous indispensable domestic implements; while the plumes of the ostrich, and the skin of the ermine, furnish the most splendid decorations to

royalty itself. Last, but not least, in the scale of usefulness, is the quill.

CHARLES.

We cannot indeed be too grateful to the feathered tribe for this little instrument, through whose medium we have obtained the stores of knowledge which we possess; and to which we are indebted for the means of communicating with distant friends, and of giving permanence to evanescent thoughts.

DR. A.

A very handsome compliment to the poultry-yard, Mr. Charles, and one which it well merits, notwithstanding the occasional use of metallic pens.

The nails are another part of the integuments, and are insensible substances, of a nature similar to scarf skin, and firmly fixed to it, so as to separate with it after long maceration. They are formed from the skin, and are lodged in a doubling of it. They consist of thin transparent plates, and are intended as a defence to the organs of touch.

SOPHIA.

Would the nails, if left to themselves, grow, like the hoofs of animals, to a great extent?

DR. A.

They would curve over the ends of the fingers, and grow till they assumed a pointed form.—Claws and hoofs are given to various quadrupeds and birds; and

where the former are required to be kept very sharp, as in animals of the cat kind, there is a little apparatus provided, by means of which they are drawn into a kind of sheath, and thus preserved from injury. In general, however, the hoofs and claws are intended to preserve the feet of animals from being hurt by walking; or to give the necessary support to the toes, in the various operations which they are intended to perform. Where the hardness of roads would wear away the hoofs, as in horses, mules, and asses, an artificial defence, in the way of iron shoes, is given, which it does not appear that the ancients found necessary, and which are, with us, sometimes taken off when animals are at grass. The ordinary use to which hoofs and claws are applied, keeps them of a proper size, and prevents any undue growth; and we may see that the claws of birds, which are intended to assist them in grasping boughs with their feet, are obliged occasionally to be cut, where confinement prevents the exercise which is necessary to wear them down.

SOPHIA.

I perfectly recollect this being the case with a favourite Canary bird, which nurse had many years since: the poor thing was often quite a cripple till its claws were cut.

DR. A.

The Romans were very particular in their at-

tention to this part of the body; and during the period of their highest luxury, their barbers had the nails particularly under their care, trimming and cutting them according to prevailing fashion. It has been said by Le Compte, that among the Chinese, in his time, the doctors and other learned men suffered their nails to grow to an excessive length, not only as an ornament, but a distinction, to show that these personages were separated from mechanical arts, and were wholly addicted to science.

HARRIET.

This was as good an ensign as the gold-headed cane and the bag wig, which physicians, in this country, had of old; though it might interfere a little, it must be owned, with the feeling of the pulse.

DR. A.

Mankind always like to have the trouble saved them of examination into professional merits; and the cane, wig, or demure looks of the European doctors, and the long nails of the Chinese, were equally a sort of sign-post of their qualifications or pretensions.

SOPHIA.

I am very glad that the fashion has altered before our time; for it would be odious to see you with those decorations, and particularly with the sombre looks which it was once thought necessary for

physicians continually to wear, and which would totally freeze and repel all approaches to that freedom of intercourse which you kindly allow us.

DR. A.

Viewing physicians as friends, or men of science, the change has been favourable; but it is perhaps questionable, how far the profession, as one of which money is to be made, has gained by the removal of those external signs of dignity and sapience, to which the public are still apt to affix the possession of superior knowledge or attainments. Besides, it is to be recollected, that the legislature, in one of its earliest laws relative to the medical profession (and which by the by is still in force), enacted, that none should be allowed to practice physic but such as were 'profound, sad, and discreet;' which shows how much the exterior of a doctor was attended to in the time of Henry the Eighth. But this opinion was of still more ancient date; for Hippocrates, whom we deservedly call the father of physic, and who lived more than two thousand years ago, in his instructions to physicians, recommends them to have a meditative and pensive cast of countenance; without, however, appearing harsh or haughty; and by no means to indulge in laughter, or to be of too cheerful a turn of mind.

SOPHIA.

But whatever the ancients may have thought on the subject, or even our forefathers in more modern times, is it possible that the public can be so ignorant, now-a-days, as to be misled by mere exterior, instead of looking to real and substantial qualifications?

DR. A.

When a person is well known, he may be properly appreciated; but it is astonishing how little will bias the opinion of patients, or their friends, in the choice of a physician, or in the estimate which they may form of him. You must not forget, too, how much the respect for judges and counsellors is increased, by the formidable magnitude of their wigs, and the graceful flowing of their robes; and there is little doubt, that a portion of their dignity and consequence would be lost, if they were to exercise their respective functions without their appropriate costume.

But the long nails of the human race, however they may have been valued as embellishments, never could be put in competition, for active service, with the claws of various animals, which are intended to assist them in securing or tearing their food, in burrowing into the earth, in climbing trees, or in fixing themselves to boughs during their sleep.

CHARLES.

I suppose the horns of animals bear a considerable similarity in their nature to nails and hairs?

DR. A.

The chemical results are the same; all of them principally consisting, as does likewise the scarf-skin, of condensed or hardened albumen; a substance which I have already mentioned to you; but horns vary very much in their mode of growth. Some, as in oxen and sheep, grow from the bones of the head, and increase in length by additions at their roots; others, as the snout of the rhinoceros, is composed of a congeries of hair, glued together, and united firmly at bottom, but attached only to the skin, and hence allowing the snout to be slightly moveable; while others, as the antlers of the stag, are deciduous, being thrown off, and supplied, every year.

HARRIET.

I recollect seeing, I think at Dr. Harwood's lectures, a section of the horn of the rhinoceros, in which the hairs were exceedingly apparent; but what an immense growth the antlers of the stag must have, to be formed in the course of a single year!

DR. A.

In point of fact, these antlers, though they sometimes weigh a quarter of a hundred weight, are

completely formed in ten weeks: they drop off in the latter part of the year, and the part from which they originate soon becomes covered with skin. At the proper season, tubercles arise at the place from which the new antlers sprout; and they, in their turn, drop off to spring anew, but always more considerable in size. It must be observed, however, that the antlers of the deer tribe are very different from common horns. But I shall have occasion to advert to this subject again, when I explain to you the nature of bone.

CONVERSATION II.

DIVISION OF ANIMALS, AND VARIETIES OF MANKIND.

DR. A.

I MENTIONED to you, at our last meeting, the five different varieties into which the human race may be divided; and it is now my intention to point out to you some of the principal peculiarities which appertain to each. Before I enter upon this subject, however, it may be useful to make you acquainted with the division, or classification of the animal kingdom, which is adopted by naturalists of the present day, because I shall frequently have occasion to refer to various parts of it, in executing the plan which I propose for you.

LINNÆUS divided the animal kingdom into six classes; viz.

I. MAMMALIA, or those animals which suckle their young; which comprehend the human race, quadrupeds of all kinds, bats, seals, and whales.

II. BIRDS.

III. AMPHIBIOUS ANIMALS.

IV. Fishes.

V. Insects; and

VI. Worms.

These classes he divided into various orders, genera, and species; and when I tell you that his six classes consist of 33 orders, 449 genera, and 19,430 species, you may well imagine, how much natural history requires the aid of method, for its successful cultivation.

HARRIET.

I am surprised to hear you comprise bats and whales in the same class with man and quadrupeds. I should have thought that bats were birds, and whales, fish.

DR. A.

Bats have no other claim to being considered as birds, than that of their being able to suspend and move themselves in the air, just as some species of fish have likewise the power of doing to a certain degree. They have membranous arms instead of wings; are covered with hair; suckle their young; and have all the other analogies of the mammalia class. Whales, likewise, differ from fish, and agree with the mammalia, in the important particulars of giving suck, and in the mode in which the blood circulates, and the respiration is carried on.

The division of the animal kingdom which is,

however, principally followed at present, is that of CUVIER, the French philosopher, who has so much distinguished himself, by his successful prosecution of every branch of anatomical and physiological knowledge: and as it is important to be well acquainted with the classification adopted by him, I shall give you a general account of it, with a more particular one of his first principal division.

Classification is, however, a thing which requires a good deal of minute attention, and I shall therefore draw out, for your use, in a tabular form, and give you, before our next meeting, the more material parts of the arrangement of both Linnæus and Cuvier, which you may look over at your leisure.

Cuvier first distributes the animal kingdom into four grand divisions, consisting of

I. VERTEBRATED ANIMALS, or those which have a vertebral column or back bone.

II. MOLLUSCA, or animals of a soft texture, having shells occasionally in some parts of their bodies, but not bones.

III. ARTICULATED, OR JOINTED ANIMALS, from the peculiar mode in which the different parts of their bodies are united together; and

IV. ZOOPHYTES, OR RADIATED ANIMALS, from the organs which they possess being placed round a centre.

The VERTEBRATED Animals Cuvier subdivides

into four classes; namely, the MAMMALIA, BIRDS, REPTILES, and FISHES.

The 1st class, the MAMMALIA, he divides into eight orders, of which he calls the

1st. *Bimana*, or the two-handed, which comprehends the human race alone: the

2d. *Quadrumana*, or the four-handed, which comprises monkeys of all kinds.

SOPHIA.

I am very glad that man has a place by himself; but I cannot understand why any animals should be termed four-handed. Are the feet of monkeys to be regarded as additional hands?

DR. A.

They are endowed with a power of grasping with the feet, as well as with the hands, by which means they possess the faculty of ascending trees with great facility. You may form a good idea of the difference between the shape of their feet, and ours, from the sketches which I now shew you; in which the first indicates the human leg and foot; the second those of the monkey, with its long and flexible toes, so well adapted for doubling upon, and grasping the boughs of trees.

The 3d order is the *Carnassier*, or Flesh-eating, which Cuvier divides into,

1. The *Cheiroptera*, or those having winged hands, of which the bat is an example.

2. The *Insectivora*, or those which live upon insects, as the hedgehog, shrew-mouse, and mole.

3. The *Carnivora*, or Carnivorous, which, again, he divides into four families; namely,

1. The *Plantigrade*, or those which walk on the soles of the feet, which, from being large, admit a great facility of standing on their hinder extremities. The bear, racoon, badger, and glutton belong to this family.

2. The *Digitigrade*, or such as walk principally on their toes, which include weasels, and animals of the dog and cat kind; as the dog, wolf, and fox; and the cat, lion, tiger, and leopard.

3. Some of the *Amphibious* animals, as seals and walruses; and,

4. The *Marsupial*, or *Pouched* animals, as the kangaroos, and opossums, which are remarkable for possessing a curious pouch, into which their young can creep for protection.

HARRIET.

I do not quite understand why Cuvier should adopt, as one of his divisions, the carnassiers or flesh-eating, and employ, as a subdivision, the carnivorous, a designation which seems to mean the same thing.

DR. A.

In using the general term carnassier, he would imply the simple fact of living on animal food; though this may consist principally of insects; but by carnivorous, he wishes to denote, not only the inclination to live on flesh, but the disposition and power necessary for obtaining such kind of food. The objection which you mention has certainly, however, much force in it.

Cuvier's 4th order is the *Rongeurs*, *Rodentia*, or *gnawers*, of which castors, beavers, rats, mice, hares, rabbits, and squirrels, are examples. They are so called, from having a remarkable power, in their front teeth, of gnawing wood.

The 5th order is the *Edentés*, *Edentata*, or *toothless*, from the animals of this order being deficient in some or all the teeth. Sloths, armadillos, pango-

lins, and the curious and anomalous animal from New South Wales, called the ornithorinchus, belong to this division.

The 6th order is the *Pachydermes, Pachydermata*, or *thick-skinned*, and comprises the elephant, hippopotamus, hog, rhinoceros, horse, and ass.

The 7th order is that of the *Ruminant Animals*, or those which chew the cud; and it comprehends the camel, the deer, the antelope, the goat, the sheep, the cow, and the buffalo.

The 8th and last order of the Mammalia, is the *Cetacea*, or *Whale* tribe, and comprehends whales and dolphins.

Having thus, therefore, given you a general account of Cuvier's first division of the vertebrated animals, I must refer you to the table which I have promised you *, for any further particulars as to classification, and shall now direct your attention to a consideration of the varieties of the human race.

These varieties are, as I have already mentioned to you, five in number.

The first is the EUROPEAN, or rather the CAUCASIAN variety; for Blumenbach, a very distinguished philosopher of Gottingen, who adopts the division mentioned by me, employs the Caucasian as the general designation; first, because the

* See Table at the end of the Second Volume.

finest specimens of mankind are found among t Georgians and Circassians, who live near Mou Caucasus; and, second, because this is not f from the region where the earth first began to peopled.

The Caucasian variety is distinguished by the shades which characterise the white; and copious hair, sometimes black, and frequently various light colours. The head is large; t upper and fore part of it particularly develope and the forehead expanded. The face is oval a straight, the features distinct, and falling perpen cularly below the forehead. These are the gene characters which attach to all the Europea except the Laplanders; to the inhabitants Western Asia, as far as the river Ob, the Caspi Sea, and the Ganges, and including therefore t Turks, the Georgians, Circassians, Arabs, P sians, and Hindoos of high cast; to the Northe Africans, and some Southern tribes; to t Egyptians, and Abyssinians; and to the Guanch or the inhabitants of the Canary Islands.

The sketch which I now show you, is that a Georgian's head, from Blumenbach's valua work on the varieties of the human race.

CHARLES.

This division then, seems to comprehend every nation which has been in any way distinguished for civilisation, in either ancient or modern times.

DR. A.

It does so; and we may add to them, the various ramifications into which the enterprise of European colonisation has carried their respective races, in North and South America, in the West Indies, in Southern Africa, and in various parts of the eastern world.

CHARLES.

But in the various nations which you have named as belonging to the Caucasian division, there must be many varieties in the respective characters of face.

DR. A.

Certainly; but still they are referable, in a

greater or less degree, to the general description which I have given. The high cheek-bones of some nations, the aquiline noses of others, and all the minuter circumstances of colour of skin and eyes, are merely varieties of the same general character.

The second division is the MONGOLIAN, or yellow, which has a middle tint between that of ripe wheat, and boiled quince, or dried lemon-peel. This variety is characterised by black eyes, black, straight, strong, and thin hair; little beard; head of a square form, with small and low forehead; broad and flattened face, with the features running together; nose small and flat; rounded and projecting cheeks; eyes placed obliquely; narrow and linear aperture of the eyelids; slight projection of the chin; large ears; thick lips.

SOPHIA.

What a frightful assemblage of features! But why is this variety called Mongolian?

DR. A.

Because it is a distinction of the Mongols, Monguls, or Moguls, who are a very numerous tribe inhabiting Central and Northern Asia. The nations comprehended under this variety are very extensively diffused: they comprise, among many other smaller divisions, the Calmucks; the Chinese, and Japanese; the inhabitants of Thibet, Cochin China, Ava, and Siam; the Laplanders, and the Esquimaux.

CHARLES.

It seems to be exceedingly curious, that the Laplanders should form an exception to the general character of the Europeans; and that these, and the Esquimaux, should have any thing in common with nations so far distant, and occupying regions of such very different temperature.

DR. A.

This is a very remarkable circumstance in the history of mankind; and it shews how pertinaciously distinctions are kept up, when nations remain unmixed.

You will observe a considerable difference between this sketch of a Calmuck's head, and that of the Georgian which I have just shown you.

The next division, the third, is the ETHIOPIAN variety. In this the skin and eyes are black; the

hair black and woolly; the skull compressed laterally, and elongated towards the front; the forehead low, narrow, and slanting; the cheek-bones prominent; the jaws narrow and projecting; the upper front-teeth oblique; the chin receding; the eyes prominent; the nose broad, thick, flat, and confused with the extended jaw; the lips, and particularly the upper one, thick. The projecting jaw, and retiring forehead of the Negro's skull, makes a great difference between this, and either of the two former sketches.

All the inhabitants of Africa, which are not comprehended in the Caucasian variety, are comprised in this.

CHARLES.

There must then, I suppose, be many varieties in this division.

DR. A.

A great number; and even some of them have, with the exception of colour, a considerable claim to personal beauty, though we should be hardly likely to expect this among the Caffres, or Negroes.

The fourth division, the AMERICAN variety, is characterised by a dark skin, of a more or less red tint; black, straight, and long hair; small beard; countenance and skull very similar to that of the Mongolian tribes; forehead low; eyes deep; face broad, particularly across the cheeks, which are prominent and rounded; mouth large, and lips rather thick. All the native tribes of America, except the Esquimaux, are comprehended in this variety; but the skin in many of them, particularly those of equinoctial America, and even of the Northern, is much more of a brown, than a copper colour.

The fifth division is the MALAY variety, and it has in it, less of a peculiar character than any of the other divisions. The colour is brown, from a light tawny, to nearly a black. The hair is black, abundant, and more or less curled; the head rather narrow; bones of the face large and prominent; nose full and broad towards the apex; the mouth large.

The inhabitants of Malacca, Sumatra, Java, and of most of the adjacent Asiatic islands; of the Molucca, Philippine, and neighbouring groupes; of

New Holland, New Guinea, New Zealand, and the numberless South Sea islands, are all of this variety; and it may be remarked, that among the East India islands, there is a division resembling the Negro in the character of the hair, in colour, and in the general form of the skull and features. Persons belonging to this division are called Negroes, or Moors, and are regarded as the aboriginals, whose ancestors were driven up to the mountainous districts, by the encroachments of new settlers.

CHARLES.

It can hardly be imagined, that the varieties of mankind which you have mentioned, should not have been very much blended together, in many places, by mixture of races.

DR. A.

This has certainly been the case to a considerable extent; but the Caucasian has been less affected in this way, on account, perhaps, in some degree, of the higher estimate in which the persons belonging to this class hold themselves, and the smaller number of the other divisions who settle among them. We find, however, that when colonisation has taken place, which it has done to a great extent from all the nations of Europe, to various parts of the world, and particularly to America, the blending of races has produced many changes of appearance.

CHARLES.

This must more remarkably be the case when different varieties live in contiguous districts, as in Africa; and I recollect that Mungo Park describes the Foulahs as being a link between the Moors and Negroes, as being of a less glossy black, having soft and silky hair, and as not having the flat noses and thick lips which characterise the Negro.

DR. A.

The Arabian and Saracen conquerors; the Phœnician, Greek, Roman, and Turkish colonists in the North of Africa; the Abyssinians on the East, and the Portuguese on the Western coast, would all likewise tend to produce differences, of a considerable extent, in the people among whom they settled.

SOPHIA.

And yet it is extraordinary how much the characters of invaders have been lost by residence in a conquered country. It appears as if a complete assimilation, in time, took place between them and the vanquished.

DR. A.

This will, of course, happen when the number is small; but in colonisation the case is different: the new comers keep a good deal to themselves, and enlarge their circles as their numbers increase; hence they often introduce a new language, and a

new race. Whereas if they went into the middle of a peopled country, as conquerors do, all traces of them would soon be lost. Blumenbach, who adopts, as I have already mentioned, the division of mankind into five varieties, considers the Mongolian and the Ethiopian as differing most from the Caucasian, and the American as coming in between the Caucasian and the Mongolian; while the Malay comes in between the Caucasian and the Ethiopian.

HARRIET.

I have heard of some philosopher who attempted to measure the comparative faculties of man and animals by a facial line and angle: what is meant by these?

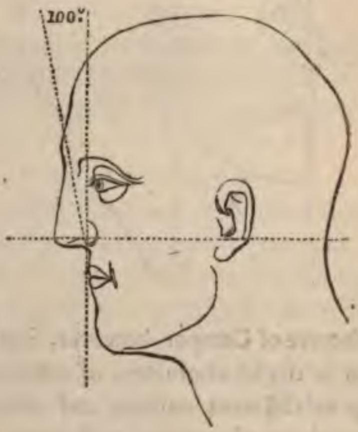
DR. A.

It was Camper; and his facial line is one drawn from the most projecting part of the forehead, to the most projecting part of the upper jaw. Now if you suppose a horizontal line to be carried backwards, from the base of the nose, to the opening of the ear, it is clear that the two lines, at their junction, will form an angle, which will be greater, according as the projection of the forehead, and the retirement of the upper jaw, allow the facial, to approach to a perpendicular line or not. You will easily understand this by a little sketch of a face in profile, in which I shall make AB the facial line, BC the horizontal line, and ABC the angle

formed by their intersection, or the facial angle. In this case, the perpendicular being DE, and the angle DEC being therefore a right angle, or angle of 90°, it is clear that the angle ABC is a little less; it is 80°.

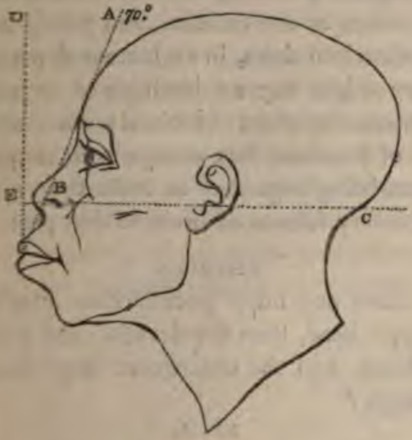
I may observe of Camper, however, that his object was rather to depict characters of countenance, as belonging to different nations and animals, than to connect these characters with any particular comparative qualifications; though, to a certain degree, this may be the effect of his system. For example, if he altered a sketch so as to make the facial line more perpendicular, and therefore to

increase the facial angle, he made it approach to the character of an antique; if he made the facial line more oblique, and therefore diminished the facial angle, he produced the countenance of a Negro. If he inclined the facial line still further back, he obtained the lines which mark an ape, a dog, or a bird. I will show you one of his sketches in which the facial line is made to incline forwards, so as to produce a facial angle of 100°.



This is the largest size which the artists of ancient Greece gave to the facial angle; and if it were still further increased, the head would appear mis-shapen, and unnatural. Another sketch of Camper's will show you the great contrast which the

Negro's face exhibits, in the retirement of the facial line, and the diminution of the facial angle, which is here only 70°.



HARRIET.

What a very extraordinary difference exists between those two characters of countenance. The projecting forehead of the one, affords a most striking contrast with the projecting jaws of the other; and it seems, indeed, as if the proportions of the face were quite reversed in them.

DR. A.

It is to be observed, however, that the ancients did not always strictly adhere to nature, in their delineations of the human countenance. In giving

a facial angle of 100° to their statues, they adopted an ideal standard of perfection, partly from a wish to remove, as much as possible, from the semblances of their great personages; the characters of the lower orders of the creation, and partly in order to transfuse into them, in an increased proportion, whatever might express intelligence or sublimity in the human species; which elevation and projection of forehead has always been supposed to do, from being regarded as indicating a greater than ordinary fulness of brain in that part.

CHARLES.

Are there any other peculiarities attaching to the antique head, than the elevation and projection of forehead, and the consequent large size of the facial angle?

DR. A.

There is a greater breadth than natural in the forehead of the antique; the orbits are large; and there is an oval form of face, with which the cheek-bones of an ordinary head would remarkably interfere.

CHARLES.

Much of the character of the Negro's countenance seems to be derived from the projection of the jaw, independently of the forehead; and if we could suppose this feature to be altered, the face would not be very dissimilar to that of many Europeans.

DR. A.

Camper gives a plate in illustration of the very point which you mention, in order to show that the face of a European may be made a Negro's, or that of a Negro, a European's, by merely contracting or elongating the jaws and lips; and that thus the facial angle may be increased from 70° to 80° or 85°, while the forehead remained the same. You will be interested in my likewise showing you a sketch of the head of an ourang-outang, from Camper, in which the facial angle is 58°, owing, as you may observe, to the great projection of the jaws; for the forehead would not discredit a philosopher.

CHARLES.

The knowledge of the facial angle seems to be very well adapted to designating a certain shape

of face; and in man, to showing differences in the fulness of the forehead; but I cannot conceive what is to be gained by comparing this angle, in animals of different kinds; as if the ape, dog, and snipe had different degrees of intelligence, depending on the different magnitude of the facial angle, and that on the mere projection of the jaws. It seems to me, that the attributes of animals of different descriptions, and totally distinct habits and modes of life, hardly admit of comparison with each other; and that quadrupeds, birds, or reptiles, may have all the endowments which fit them, in the highest degree, for the purposes of their creation, without any reference to the comparative state of their facial angles. But I would beg to ask, whether, in children, the facial angle is not greater than in grown people?

DR. A.

Considerably; and this is to be attributed a good deal, to the difference which exists in the shape of the skull and bones of the face, at different periods of life. The prominence of forehead, and roundness and plumpness of face which distinguish infants, arise from the scantiness of the jaw, and the want of teeth; and gradually give way to a certain squareness of countenance, as soon as the jaws elongate, become larger, and obtain teeth. The cheek-bones then increase in magnitude; the eye-brows become projecting; and as the mass of fore-

head remains the same, the jaws are projected forward, and therefore alter the facial angle.

CHARLES.

Is the difference which occurs in the shape of the heads of inhabitants of different countries, natural, or does it depend on various habits of dress or management, which give a direction to growth, during the period at which the head may be susceptible of some change of form?

DR. A.

There seems to be a good deal of this the result of original natural conformation; but some nations, who admire flatness and lowness, instead of elevation of forehead, make an artificial pressure on the heads of their infants, by means of which the head is made broader, by the contents of it being thus directed laterally. This is the case with the Caribs, who were the original inhabitants of the West India islands, at the time of their discovery by Columbus; and who resemble, a good deal, some tribes who occupy the neighbouring continent, north-east of the sources of the Orinoko. This practice, however, does not appear to have been confined to them, but to have been employed in Peru, Brazil, and Lima; for more than two hundred years ago, it was prohibited by an edict of the synod of Lima; which shows that this custom was in use from the earliest periods of the history of these regions. Even in modern times, the prac-

tice is not extinct; for Messrs. Lewis and Clarke, in their Travels to the Source of the Missouri, mention that it is in general use among the natives west of the Rocky mountains, who are called flat heads by the nations east of them, among whom the fashion is totally unknown. These gentlemen have also observed the existence of the same habit among some other tribes of the native Indians; and they mention a female, in whom the depression of forehead was so great, as to form a straight line between the eyebrows, and the crown of the head. — The sketch which I now show you, is that of the skull of a Carib chief of the island of St. Vincent, from Blumenbach, which was taken up many years since, by desire of Sir Joseph Banks. The flattened forehead is very well designated in it.

It appears, likewise, that among some of the Asiatic nations, the practice of altering the shape of the skull by pressure, in different ways, at one time existed.

HARRIET.

We hear occasionally from travellers, of persons of extraordinary size. Is this a very usual circumstance? The freedom which there is, in savage life, from all sorts of restraint, must, I suppose, be favourable to height and vigour.

DR. A.

So it is often thought, but without proper foundation. Some nations, it is true, are remarkable for stature, as well as strength of body, as the Patagonians, the Caribbees, and the Cherokees among the Americans, the inhabitants of some of the South Sea islands, and the Caffres in South Africa: but savage tribes are, upon the whole, neither particularly distinguished for height, nor strength. Many, as the Esquimaux, are remarkable for diminutive forms; so are the Bosjesmans in South Africa; and the Mongols, Calmucks, and other tribes of Central Asia, are, in general, shorter than Europeans. The Virginian, or Kentuckian, is generally an overmatch for a native Indian; and the same inferiority of physical force was not only observed by the Spaniards, among the natives on the discovery of America, but has been

remarked by various travellers in the North American continent. M. Perou endeavoured to form an estimate of the comparative strength of the arms of 12 natives of Van Diemen's Land, of 17 of New Holland, of 56 of the island of Timor, of 17 Frenchmen belonging to the expedition, and of 14 Englishmen in the colony of New South Wales. He employed an instrument which he called a Dynamometre, or a measurer of power; which was so constructed as to indicate, on a dial-plate, the relative force of the individuals submitted to experiment.

The relative forces of the Frenchmen and the English, exhibited powers as 69 and 71; while the natives of Van Diemen's Land, New Holland, and Timor, were as low as 50, the two first, and 58 the last.

CHARLES.

The precarious subsistence of many savage tribes, must be very unfavourable, I should think, to vigour; and it is quite miserable to read of the difficulties which the Bosjesmans, and the natives of Van Diemen's Land and Terra del Fuego, have, in procuring a bare and scanty subsistence.

DR. A.

Something is unquestionably to be attributed to this cause; but much likewise to difference of race. We must, however, defer the prosecution of the subject till our next meeting.

CONVERSATION III.

VARIETIES OF MANKIND CONTINUED.

CHARLES.

At the conclusion of our last conversation, you spoke of different races of men; but surely we are not to regard mankind otherwise than as descended from a single pair?

DR. A.

Certainly not; but then we have many varieties, as I have already mentioned, differing much from each other; but still not more than we continually find among many animals which were originally of the same stock.

CHARLES.

I have often thought how singular it is, that the various nations of the world, differing from each other so much in external appearance, should all of them have originated from two individuals. I suppose these differences are produced by the different effects of climate on the human body.

DR. A.

Such has been the opinion of many philosophers of great eminence, both in ancient and modern times; but yet it is not borne out by an attentive examination of facts.

CHARLES.

But is it not found that complexions darken as you approach the torrid zone, and that the darkest colour is in the warmest latitude? Thus we see, that the Norwegians and Danes are fairer than the English; the English than the French; the French than the Spaniards and Portuguese, and these than the Moors; while the Negroes in the burning regions of Africa are darkest of all? We even observe, that in this country, exposure to the sun darkens the complexion; and a European who is much abroad, acquires an approach to the colour of the inhabitants of his adopted residence.

DR. A.

You have put the case strongly; and we must admit, to a certain degree, the correctness of your facts, without however going to the extent of your conclusions. The influence of the sun is unquestionable on the parts which are exposed to it; but only on those parts. Captains Lewis and Clarke were so much browned during their expedition to the Missouri, as to be often taken, by the natives, for Indians belonging to hostile tribes; and it was only on showing the whiteness of their skin in such parts as were covered, that their suspicions were removed. In Lord Amherst's expedition to China, it was observed, that persons who were in the habit of working in the heat of the sun, with their bodies uncovered from their

s of the skin which was usually covered, n the appearance, at a distance, of wearing oured pantaloons. In all these instances, e rays of the sun heighten the usual com- the effect goes off, and in time the usual s resumed; while those who are not so as women and children, remain of the olour of the race.

SOPHIA.

nay not the long continued operation of ause, in time produce on their successors hich would not be fully produced on the al? I think I have read of a colony of ese who settled on the coast of Africa ındred years ago, and whose successors the complexion and features of Negroes?

DR. A.

ıre quite right in your recollection of this t; but then, unfortunately for the reason- change was produced in consequence ıually marrying with the natives; and it

SOPHIA.

But is it the fact, then, that when persons are transplanted into a very different region, whether from a colder to a warmer, or from a warmer to a colder latitude, their successors will remain of the same colour as their original parents?

DR. A.

This seems, from a very extensive deduction of facts, to be the case. I have already noticed the small stature, and olive, or swarthy complexions of the Laplanders and Esquimaux, which evince their Mongolian descent, though the Norwegians or Americans are their immediate neighbours, who live in a latitude not materially different from them. Europe itself, in its subdivisions of inhabitants, affords a striking example of the continuance of the different character of its inhabitants from the earliest periods. The Celtic, the German, and the Sclavonic races, have all of them preserved the great distinctions of physical character, which they are described to have had at the time of Cæsar and Tacitus.

HARRIET.

But are we enabled to recognise, at the present day, any of the descendants of those ancient people?

DR. A.

The Celtic race occupied the Western parts of Europe, and its decendants, with the characteristics of black hair, and rather brown skin, still occupy

France, Spain, Portugal, and Italy. The Ancient Britons, the Gaels, the Irish, the Scotch, and the Manx, were a part of the same people; and it is said that vestiges of the same character are to be still found among them.

CHARLES.

Perhaps the designation of Dhu, or black, may be given to those tribes of Highlanders who possess this character in the most marked way.

DR. A.

Not improbably. The German race have, as their descendants, the Swedes, Norwegians, Icelanders, Danes, the inhabitants of the various parts of Germany, the English, and the Lowland Scotch; and the fair complexion, blue eyes, and yellow, or reddish hair, have passed on from ancient to modern times.

But the eastern parts of Europe were anciently, and still continue to be, occupied by people of a darker complexion, and of Sclavonic origin, as the Poles, Croats, Bohemians, and Bulgarians; which is the more remarkable, because these nations are close neighbours to the Germans, who have ever preserved a very different character. This is likewise the case with the Russians, with the exception of the peasantry in the North, who have frequently light brown, or red hair.

The gipsies afford a remarkable example of the force with which original characteristics adhere to the human body, under every change of climate.

Those people have been, for centuries, dispersed over every part of Europe, distinguished by colour, contour of features, and language, from the nations with whom they lived. They appeared in Europe about the beginning of the fifteenth century, and their origin was long unknown; but at length it has been ascertained, in part from colour and bodily formation, but principally from the affinity of language, that they sprang from some of the castes into which the Bazeegun Hindoos are divided. The gipsies are called the Siscch Hindu, or Black Hindoos, by the Persians; and though there is some alteration of character, of countenance, and complexion, among the gipsies of the present day, owing in part, perhaps, to intermixture with foreign blood, yet they are occasionally seen with very dark complexions, and with every appearance of Oriental origin.

SOPHIA.

Do we find in countries where the inhabitants are usually dark coloured, that the light complexion is preserved for long periods of time?

DR. A.

In the island of Sumatra, children born of Europeans, are as fair as those born in the country of their parents; and so their successors have continued to be. On the other hand, the children of Negroes remain as black as ever. The same happens in the West Indies; and to show that

the effect is not lost, there are some families in Jamaica, whose predecessors left England at the time of the grand rebellion, and yet they continue to be as white as Europeans. A similar circumstance has been mentioned of the descendants of Spaniards in South America. The Anglo-Americans have likewise made no approach to the colour of the American Indians, however long may have been the period since they have quitted Europe.

CHARLES.

But do not the Jews, who are diffused over every part of the world, and whose religion prevents them from intermarrying with any but their own race, acquire the colour of the inhabitants where they dwell?

DR. A.

This is a mistake; they become brown, by exposure, as Europeans do; but their children are born fair, and the black colour of the hair, and the peculiarity of countenance, are preserved, in all parts of the world, in remarkable purity. There is a very curious example of the steady adhesion of such characteristics, mentioned by the well-known traveller in India, the Rev. Dr. Claudius Buchanan. He states that at Cochin, on the Malabar coast, there is a settlement of Jews, who, it appears by their records, migrated to India soon after the destruction of the temple by Titus Vespasian, and

who resemble the European Jews in complexion and features. They have kept their race distinct, and are called white, or Jerusalem Jews. There is, however, at the same place, a tribe of Jews, whose ancestors intermarried with the natives, and who have, in consequence, acquired the Hindu complexion and features. They are called black Jews, and are regarded as an inferior cast.

CHARLES.

When intermarriage takes place between whites and people of colour, and this goes on in either direction, the offspring will, I suppose, in a very few generations, acquire the full white, or black colour, as the case may be.

DR. A.

The period at which the complete change will be effected, is pretty well known in the West Indies and Spanish America; and there are particular terms, by which all the intermediate shades of colour between black and white, are designated. For instance, a child born of a Negro and European is called a Mulatto, and has equal parts of white and black blood. A child born of a European and Mulatto is a Terceron, and has three-fourths white, and one-fourth black blood. A child born of a European and Terceron is a Quarteron, having seven-eighths white, and one-eighth black blood. And one born of a European and

Quarteron is a Quinteron, having fifteen-sixteenths white, and one-sixteenth only black blood, and is considered as white by law, and free.

On the other hand, if a Mulatto intermarry with a Negro, the offspring darkens in the same proportion as it becomes fairer if the marriage was with a European; but the first step only has a name, the Griffo or Zambo, which has three-fourths black, and one-fourth white blood. Humboldt states, that in Spanish America, the greater or less degree of whiteness of skin decides the rank of an individual in society. A white who rides barefoot on horseback, thinks he belongs to the nobility of the country, and will often say to a great man, if he have a dispute with him, Do you think me not so white as yourself? It becomes therefore an interesting object, to estimate accurately, the fractions of European blood which belong to the different casts; and in Spanish America, they have numerous denominations for the offspring of Indians, as well as Negroes, with Europeans; and every person is so jealous of the honour of his tribe or cast, that if, through inadvertence, you call him a degree lower than he actually is, he is highly offended. It sometimes happens, that families suspected of being of mixed blood, demand from the high court of justice, to have it declared that they belong to the whites,

which, when they are rather swarthy, is termed "getting themselves whitened." When the colour of the skin is rather too repugnant to the judgment demanded, then the petitioner is satisfied with an adjudication, "that he may consider himself as a white."

SOPHIA.

You have, I think, very clearly shown, that the influence of climate does not produce any very essential differences among mankind, and cannot therefore give rise to the varieties which we observe among them; but I am exceedingly anxious to know on what those differences depend.

DR. A.

This is a very curious and interesting problem, and one which cannot, in every respect, be satisfactorily answered. There are, however, several important particulars known relative to this subject.

We have seen that the differences which climate produces in the colour of the body, wear off, or terminate with the individual: they are not capable of being transmitted to the offspring. Whatever effects art or accident may produce on the individual, are personal, and go no further; for otherwise we should see, that all those changes and mutilations, which the perversities of fashion produce, both on man and other animals, in all parts

of the world, would form permanent varieties among them. Thus the flattening of the heads among the Caribs, the contraction of the feet among the Chinese, the elongation of the ears among some, the perforation of the nose and lips among others, require all of them to be repeated on every individual, when such fashions are to be kept up. In the same way among animals, docking and cropping make no alterations in the tails and ears of the breed; and it is fortunate that it is *so*; for otherwise we should have the beauty of natural shape, permanently superseded by the wildest aberrations of vitiated taste. When, on the other hand, there is any peculiarity of form born with the individual, such peculiarity is capable of being transmitted to the offspring; and though we cannot trace all the steps by which changes are carried on, until they arrive at the production of permanent varieties, yet we can in many instances. Naturalists suppose that our sheep, our dogs, and our horses, were severally derived from one original stock; and yet what great variety there is in the respective breeds, and how separate they continue, provided they are kept distinct. We can even contrive to have the advantages of particular breeds blended for particular purposes, if we so wish it; and hence the permanent improvement which has been made among many

breeds of animals, and especially sheep, of late years, by agriculturists in this country.

CHARLES.

I can easily conceive that a mixture of breeds which already exist, may, in time, produce an union of the excellencies of particular ones; but are instances known of entirely new varieties being formed? for we must look, I presume, to such occurrences, to throw light on original differences in the same breed.

DR. A.

We have a very curious and well authenticated instance of a new breed of sheep occurring in America, from an accidental variety which appeared in a flock in New England. The characteristic of this variety was very short legs, particularly the fore legs, and a bend in the middle of them, somewhat like an elbow. Now, as the fences in New England were low, and were of wood or stone, it was thought desirable to have sheep which could not readily get over them. Breeding from this animal was therefore encouraged, and a flock of this breed, called ankon, from a Greek word signifying elbow, was in a few years obtained. — The Dorking fowls afford an example of a supernumerary claw being peculiar to one particular breed; and there are various other

striking peculiarities in different breeds of the common fowl. Some are very large, others dwarfish, as the Bantam; some have double combs; some are tufted; some are without rumps; and there is a very curious variety in Padua, in which a sort of appendage to, or dilatation of skull exists, in the upper part of the head.

CHARLES.

I suppose Albinoes are perpetuated in a similar way, among such animals as exhibit this peculiarity?

DR. A.

Exactly so; and we even observe in mice, the immediate occurrence which, as in the ankon breed of sheep, produces so remarkable a change in the character of the animal; for mice, when confined in dark places, have been found to produce a white breed with red eyes: and this character would go on, until interrupted either by crossing, or by a new occurrence in some of the future progeny. The Albino variety is very abundant among animals, and the white rabbit is a familiar example in this country. Almost all animals exhibit occasional varieties of the same kind. Thus they occur in cats, dogs, oxen, asses, sheep, and hogs, among the domesticated animals: among monkeys, squirrels, rats, hamsters, moles, opossums, weasels, martins, and polecats, of which last the common ferret is

supposed to be the white variety. They are likewise occasionally found in the buffalo, roe, camel, elephant, rhinoceros, stag, and jagen of Mexico; in the common bear; and in the badger and beaver. Albinoes have been found also among various species of birds; as crows, blackbirds, Canary birds, partridges, common fowls, and peacocks, having their feathers of a pure white colour, and their eyes red.

CHARLES.

Circumstances of deviation from usual structure must doubtless be found likewise in the human race?

DR. A.

Many peculiarities have been observed in them, as well as in the brute creation, which are capable of being perpetuated. Family likenesses are a familiar example: so is hereditary stature, whether large or small; and it is curious how long peculiarities of features may continue in the progeny. The thick lip, introduced into the house of Austria by the marriage of the emperor Maximilian with Mary of Burgundy, is visible in their descendants, even after a lapse of three centuries. Many instances have occurred, both in ancient and modern times, of peculiarities of structure being handed down from the parent. Thus the occurrence of six fingers, or six toes, is not uncommon. Such

persons were called, among the Romans, sedigiti, or sedigitæ, six fingered men or women. Sir Anthony Carlisle has recorded the transmission of such a variety for four generations.

I met myself, some time since, as you may recollect my mentioning to you at the time, an Irishman from Killarney, who had a thumb, and only two fingers, the third and little finger, on each hand; and only the large and small toe on each foot. The two fingers were united with each other; were permanently bent inwards; and were anchylosed, or stiffened, at the second joint, so as to have no motion in it. The metacarpal and metatarsal bones (those to which the fingers and the toes are united) were covered with integuments, which had not the smallest appearance of cicatrix or scar, to give any idea of the fingers or toes having ever been removed. This person's grandfather had one thumb on each hand, and no fingers; his father was like himself, both as to toes and fingers. He had many brothers and sisters, none of whom had any peculiarity; and of his own children (of whom there had been fifteen, though three only were living) the eldest son was the only one who had any peculiarity, and he wanted the middle toe on each foot.

The transmission of a peculiarity, for no less than nine generations, is mentioned as having occurred at Iver, near Uxbridge. The mother and several children had only the thumbs perfect; and

instead of fingers, they had only the first bone of each finger, and the first and second bones of the third finger of the left hand. The fingers had no nails. Such was reported to have been the state of the family, with slight variations, for nine numerous generations of their immediate ancestors; and it was observed by the mother, that the females only of the family, transmitted this peculiarity. No great inconvenience was stated by her to be felt from the want of so many joints, as the advantage of perfect fingers had never been experienced.

HARRIET.

Since peculiarities of form are so easily produced and transmitted, the same, I suppose, may happen with diseases, or tendencies to disease?

DR. A.

I have no doubt that tendency to disease, as depending upon a certain constitution of frame, may be handed down from parent to child; and some instances have been stated of diseases themselves, being so transmitted. There is no question, from what I have mentioned to you, that various malformations are also capable of transmission; and the same has likewise occurred, in numerous instances, of defects in structure, affecting function, and therefore amounting, to a certain extent, to disease. This has been the case remarkably with cataract, and some other defects of vision; and from the

circumstance of several individuals in the same family being frequently deaf and dumb, it is very likely that a tendency to this lamentable deprivation of sense, may be found to exist in particular families.

I have already mentioned to you the accidental occurrence of Albinoes in the human race, and how readily similar varieties are produced in other animals. Among all the nations of the world, this peculiarity is found to take place; but in many regions, there are particular tribes of Albinoes, which preserve their characters unimpaired, while they continue to intermarry with each other; and they are most frequent in those countries which are inhabited by a dark coloured race.

An Albino race has been long known among the copper coloured Americans of the Isthmus of Darien. Their bodies have been described as milk white; their eyes as red and tender; and they were called moon-eyed, because they were best able to see in moonlight, during which they were active and lively, though they were dull and sluggish during the day. They amounted to about a couple of hundred, when the account was first given of them, more than a hundred years since; and were more delicate than the other natives, by whom they were not much esteemed, being considered as something monstrous.

Captain Cook saw a few Albinoes at Otaheite; and in Java, Ceylon, and the neighbouring islands, as well as the continent, they are well known, and are termed Chakrelas or Cockroaches. They are viewed with horror by the Hindoos; and at their death are cast on a dunghill, or are left to be eaten by wild beasts.

In Africa, Albinoes frequently occur among the Negroes, though there does not appear to be any particular race of them; but even at Darien, now and then black children arise from Albino parents. There seems, upon the whole, to be rather a defect of general vigor in the Albino, connected, in some degree, with the want of the peculiar secretion on which colour depends. White hairs are often regarded as indicative of want of power; which is the case with white legs in horses.

I have already observed, that the hairs which are supplied, in this animal, in cases of injury, are grey; and that animals in high latitudes become white in winter, from a temporary defect in the secretion of colouring matter, which seems to be interrupted by cold; in old age this effect is connected with diminution of general vigour, and is permanent.

HARRIET.

Are we to regard the early occurrence of grey headedness, as a proof of less than usual general

strength? we very often see grey hairs among very young, and very strong people.

DR. A.

In such cases, I should only view it as a peculiarity of the part connected with the production of colour, and nothing more.

SOPHIA.

I have sometimes seen very fair young people with silvery locks, but nothing peculiar about the eyes. They are, I suppose, an approach to the Albino?

DR. A.

Certainly; and such an approach is very frequent, both among men and animals, and is continually observed among rabbits.—But one of the most remarkable instances which the history of mankind affords, of the production and perpetuation of an extraordinary deviation from what is usual in the human race, is afforded by a family whose case I have already alluded to; and you will be interested in hearing something more of it. In the year 1731, a boy of fourteen, named Edward Lambert, from the neighbourhood of Euston Hall, in Suffolk, was exhibited to the Royal Society, all whose body, except the face, the palms of the hands, and the soles of the feet, was covered with a dark brown thick case, exactly fitting every part of his body, made of a rugged bark or hide,

like united warts, callous and insensible, and in some places covered with bristles, which rustled like those of the hedgehog or porcupine. This curious covering was shed and renewed annually. He was afterwards exhibited in London when he was forty years of age, under the name of the Porcupine Man. He had had six children, in all of whom the same peculiarity of integument began to exhibit itself about nine weeks after birth. One of them only was living. Many years afterwards, about the beginning of this century, John Lambert, aged twenty-two, and Richard, aged fourteen, grandsons of the original Porcupine Man, were exhibited in Germany, and a minute account of them, with plates, was published by Professor Telesius.

It is clear, therefore, that if such a variety had occurred in a different period of society, and under circumstances conspiring to favour its distinct perpetuation, races of men might have been found, much more different from any yet known, than any of the present varieties of mankind are from each other. It is rather singular that more has not been heard of this family; for the elder brother was married, and his wife was pregnant at the period mentioned.

CHARLES.

But all these differences which you have mentioned in man and animals, relate to the production

and perpetuation of something defective, or unnatural in structure or appearance. Are we then to suppose, that the most perfect form of man, the Caucasian, was the original one, and that all the varieties which occur among mankind, have been produced by accidental differences, which have been kept up and perpetuated in their descendants?

DR. A.

The subject is full of difficulty and obscurity, as you may suppose, when I tell you, that some very ingenious men are of your idea; while others, from the analogy of animals in which changes of colour usually take place from darker to lighter tints, suppose that the primitive stock of men were black, and that it was by gradual improvements in this race, that the more perfect varieties of form have arisen.

HARRIET.

This would not have been a very favourable theory for Milton, whose descriptions of hyacinthine locks and golden tresses, and of all those circumstances of male and female form and complexion, in which we consider beauty to consist, must have been superseded by pictures of curly hair, thick lips, and sable visage.

DR. A.

And yet ideas of beauty vary very much among

different nations; so that if Milton had been an Ethiopian, or a Chinese, his descriptions would have been a little different from what, as a European, he made them.

It is impossible to ascertain the original form of the various breeds of animals which now fill the earth, or to trace the changes by which a difference in character has been produced among them. Much of what is stated by naturalists on these subjects, however probable, is, to a certain degree, hypothetical; and we must very generally be satisfied with analogies instead of proofs.

That nature delights in variety, is very apparent; for of the myriads of human beings who have appeared on the face of the globe, not one has ever been precisely alike in form or features. While, therefore, there is a general form and appearance adhered to in the succession of the human race, there is a certain latitude afforded for changes among them, though we know not to what extent this may go, or by what progression the original form of our first parents should, in the course of ages, have deviated into all the varieties which at present distinguish mankind. We have, however, gone rather further than was my intention, into the natural history of man; though I should hope, that the general view which I have given you of this subject, and for much of which I am indebted to the able works of Mr. Lawrence and Dr. Prichard,

changes, however, we cannot trace; but the domestic pig has been variously altered, in the various regions where it has been domesticated, both in the form and colour of its body; and yet the wild boar, from which it seems very certainly to have derived its origin, possesses very much the same general character, wherever it is found. The pig, indeed, affords the best example of a well ascertained change, effected in no very long period, in the appearance of an animal. It was known that pigs did not exist in America at its discovery by the Spaniards; but they have degenerated into breeds very different from each other, and from the original stock. Some that were taken over in 1509 to the island of Carbaguo, then celebrated for its pearl fishery, degenerated into a race with toes half a span long: and those of Cuba became more than twice the size of their European progenitors. In Hungary and Sweden, large breeds are found with solid hoofs, which is a peculiarity that was known among the ancients, and occurs sometimes in England. In Guinea, the hog has long ears, couched on the back; and in China, a large pendent belly, and very short legs; while at Cape Verd, and some other places, it has very large curved tusks, like the horns of oxen.

It seems as if regular and improved nourishment, and protection from the inclemencies of

which, in a warm atmosphere, or by a change to one, would be coloured; and, in the torrid zone, the soft fleece of the sheep is lost, which would be recovered, if taken where its warmth is necessary as a defence against the weather.

Civilization produces, among men, what domestication does among animals; and, indeed, a change from a savage, to a civilised state of existence, may, from the influence of moral causes, be fairly expected to be greater among the former, than the latter. I shall mention a few of the more striking instances, in which a certain degree of civilization, seems to have a certain physical effect on the body. The inhabitants of New Zealand, in the Pacific Ocean, all of them very much resemble the negro in colour, hair, and form of head. The Society Isles are peopled by a tribe of the same race which furnished the population of New Zealand; and the lower people resemble the New Zealanders in complexion and appearance; but the higher classes are gradually getting a fairer skin, and some of them are even approximating, in complexion and hair, to the German, or Teutonic race. It has been observed, too, that in the United States of America, the field slaves, who live on the plantations, retain pretty nearly the rude manners, and much of the structure and appearance of their original ancestors. On the other hand, the domestic servants, who

CONVERSATION IV.

OF THE BONES.

DR. A.

After having explained to you the nature of the integuments, and given you an account of some of the principal circumstances relating to external form and appearance, I shall endeavour to make you acquainted with the parts which form the foundation of the body, namely, the bones.

These are intended by nature to give solidity to the frame, and to afford a ready means of insertion for the muscles, or those parts which are concerned in motion. They likewise protect, in various instances, important parts contained within them; and, by a happy adaptation of their extremities, in the joints, allow all those changes of position which are continually necessary to us.

HARRIET.

But would you not find it more convenient, after treating of the external parts of the body, to go to the inferior parts in succession, and to arrive last of all at the bones, as the basis?

DR. A.

It is exceedingly difficult, in an endeavour to

of the works of the Creator, will find their account, in overcoming the reluctance to inspect any thing which has actually belonged to the animal creation. But though you may, perhaps, still shudder at a real skeleton, you will not be alarmed at drawings of one, on which I can point out much of what will illustrate the subject of our conversation.*

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* EXPLANATION OF PLATE I.

BONES OF THE HEAD AND NECK.

1. Frontal bone.
2. Parietal bone.
3. Temporal bone.
4. Malar, or cheek-bone.
5. Upper jaw.
6. Lower jaw.
7. The seven cervical vertebræ, or bones of the neck.

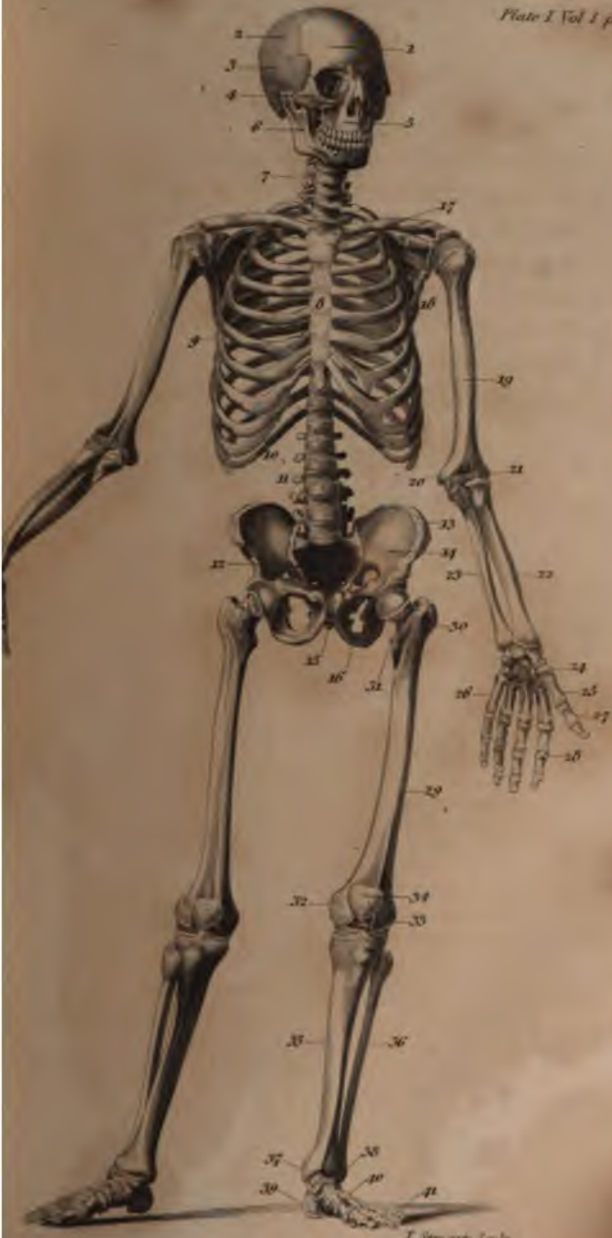
TRUNK.

8. Sternum, or breast-bone.
9. Seven upper or true ribs, so called from being united to the sternum.
10. Five lower or false ribs, from not extending to the sternum.
11. Five lumbar vertebræ, or bones of the loins.
12. Os sacrum, or sacred bone, from its being used in sacrifices.
13. Bone forming the pelvis with the os sacrum, and called os innominatum, or nameless bone. It is divided into,
14. Hip bone, or os ilium;
15. Os pubis;
16. Haunch bone, or os ischium.

UPPER EXTREMITY.

17. Clavicle, or collar bone.
18. Scapula, or shoulder blade.
19. Shoulder bone, or os humeri.
20. Its inner eminence, or condyle.
21. Its outer eminence, or condyle.

Plate I Vol I page



J. Stewart Sculp.

London, Published by Longman & C.o Paternoster Row

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Plate II. Vol.


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You see that the skull or cranium [Pl. I. No. 1—3. and Pl. II. No. 1, 2.] which contains the brain, is fixed at the top of the vertebral column, or

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22. Radius.
23. Ulna.
24. Wrist, or carpus, composed of many small bones.
25. Metacarpal bone of the thumb.
26. Metacarpal bones of the fingers.
27. Thumb.
28. Fingers.

LOWER EXTREMITY.

29. Thigh-bone, or femur.
30. Trochanter major, or larger process of the thigh.
31. ——— minor, or lesser ditto.
32. Internal condyle.
33. External condyle.
34. Patella, or knee-pan.
35. Tibia.
36. Fibula.
37. Inner ankle.
38. Outer ankle.
39. Heel, or os calcis.
40. Metatarsal bones of the toes.
41. The toes.

PLATE II.

BACK VIEW OF THE HEAD AND NECK.

1. Parietal bone.
2. Occipital bone.
3. Malar bone.
4. Lower jaw.
5. Cervical vertebræ.

THE TRUNK.

6. The ribs.
7. The twelve dorsal vertebræ, or bones of the back.
8. Lumbar vertebræ.
9. Os sacrum.
10. Os coccygis, or small bone appended to the lower part of the sacrum; so called from its resemblance to a cuckoo's bill.
11. Os innominatum.
12. Os ilium.
13. Os pubis.
14. Os ischium.

bones of the back, [Pl. I. No. 7, 11. and Pl. II. No. 5, 8.] in the centre of which is a hollow space, destined for the reception of the spinal marrow, a substance which is a prolongation of the brain, and resembles it a good deal in nature and function.

At a little distance from the skull, commence the ribs, [Pl. I. No. 9, 10. and Pl. II. No. 6.] which are fixed behind, to the bones of the back, and the greater number to the breast-bone before; [Pl. I. No. 8.] Their curvature forms a cavity, which is called the chest, and contains the heart and lungs.

At the lower part of the vertebral column is placed a firm, thick, strong, and irregular bony

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UPPER EXTREMITY.

15. Clavicle.
16. Scapula.
17. Shoulder-bone.
18. Its inner condyle.
19. Its outer condyle.
20. Radius.
21. Ulna.
22. Wrist.
23. Metacarpal bone of the thumb.
24. Metacarpal bones of the fingers.
25. Thumb.
26. Fingers.

LOWER EXTREMITY.

27. Thigh.
28. Trochanter major.
29. ——— minor.
30. Inner condyle.
31. Outer condyle.
32. Tibia.
33. Fibula.
34. Inner ankle.
35. Outer ankle.
36. Tarsus, or ankle, composed, like the wrist, of many small bones.
37. Metatarsal bones.
38. Toes.

structure, called the hips, [Pl. I. No. 12—16.; and Pl. II. No. 9—14.] which encircle a sort of hollow space termed the pelvis or bason, from containing the lower part of the intestines, and some other important organs.

At the upper part of the ribs are fixed the shoulder blades, [Pl. I. No. 18. and Pl. II. No. 16.] into which the upper extremities are articulated or jointed; and at the lower part of the pelvis are articulated the lower extremities.

By the front and back views, and the particular explanations which I have annexed to them, you will be able to form a general idea of all the most material parts of our bony structure.

HARRIET.

There seems to be a great difference in the degree of protection which is afforded to the contents of the head, and those of the chest, though one would think that the heart was one of the most important parts of the body.

DR. A.

So it is; but then in the chest, there is a certain motion required, on account of the alternate dilatation and expansion of the lungs by respiration, to which a fixed and unyielding cover would be totally adverse. The cover is, therefore, composed of separate pieces, with muscles interposed; and the

whole calculated for the degree of motion which the action of respiration requires.

The form, magnitude, and mode of junction of bones, vary, according to the design which they are intended to serve. Where length is required, with flexibility at particular parts, we have bones, like those of the arm and leg, of firm texture, with joints at certain intervals. In the hand and foot, there is, by means of the numerous joints of the fingers and toes, and of a curious mechanism of bony structure between those parts and the wrist and ankle, a facility given to the various important actions of the hand, and to the more limited motions of the foot.

In the back, great solidity is required, and the motion in any one part of it is very small. In some of the joints, the power of motion is in all directions, as in the shoulder and hip; while in the elbow and knee, there is only the power of bending or extending them.

HARRIET.

One feels, indeed, as if a greater latitude of motion, particularly in the knee, would diminish stability; and therefore it seems to be wisely in-ended, just to give the kind of motion which convenience requires, at the same time that the utmost regard is paid to firmness, and steadiness of position.

DR. A.

This is the object which nature has continually in view, in regulating the motions of the body; and the machinery employed is that which, in every way, is admirably adapted for the purpose.

The joints which compose the shoulder and hip, are of the description which is called, in mechanics, the ball and socket; and they are adapted to the exercise of motion in all directions. The hip, as it is used in supporting the weight of the whole body, is very deep-seated, and has every resource employed in it, for the purpose of giving it firmness, and preventing displacement. It is fixed in a deep groove, as you may see in the sketches, with the bony edge a little lower toward the inside, in order to admit of motion in that direction; and it is secured by large masses of thick muscles, which lie over it. The shoulder-joint, on the other hand, is superficial, and has a very shallow socket, so that its motions are among the most free and extensive of any joint in the body. To render them still more so, it is attached to the shoulder-blade, [Pl. I. No. 18. and Pl. II. No. 16.] a subsidiary bone, which lies loose over the back, so as to increase materially the latitude of motion of the arm. The shoulder-blade again is attached, by means of the collar-bone, or clavicle, [Pl. I. No. 17. and Pl. II. No. 15.] to the upper part of the breast, where there is a small joint, which may be

said to be a hinge, on which the whole arm moves. You will easily understand this by the sketches; and may, at the same time, readily feel on yourselves, how all the parts which I have just mentioned, are concerned in the motion of the arm.

CHARLES.

On putting the hand upon the collar-bone, and moving the arm, it is quite obvious, that the hinge at the breast, is very important for facilitating the motion of the arm; a circumstance which otherwise hardly enters into the contemplation. But in what way are the joints attached to each other? A workman uses some sort of pin to keep his joints together. Does nature employ a resource of this kind, or are the joints merely kept together by the muscles which surround them?

DR. A.

Nature employs what are called *ligaments*, or *binders*, for the purpose of attaching joints together; and there is one particular kind which is known by the name of capsular ligament, which is common to all joints. It is so termed, from its inclosing the joint in a kind of purse, or thin and firm membranous bag, which is fixed at a little distance from each contiguous extremity of every joint, all around the bone. In this way, it is clear, that the two extremities of bone are kept together by a contrivance, which leaves the motion of the

joint quite free. But this capsular ligament is not of itself sufficient for retaining the joints in their position, and giving sufficient firmness to their movements. There are other ligaments which go from one bone to another, and fix them securely together; and these generally have their names either from their shape, or their position.

CHARLES.

One sees in the joints which come under observation at table, that there is a gristle which covers the ends of the bones which are connected together; this is, I suppose, for the purpose of making them move easily upon each other.

DR. A.

Just so. These gristles are called *cartilages*, and are always employed to cover parts which are intended to move on each other. For a bone, however smooth it may be, is not at all adapted to move on a surface of bone; not only because it is rough, but because it is unyielding. A smooth surface of cartilage would not, however, of itself, answer the purpose of giving sufficient facility to motion. In the delicate movements of nice machinery, oil is employed to diminish friction, which must, from time to time, be renewed; or otherwise the machine will be retarded, or stop. Nature has wisely provided the cavity of a joint with a continual supply of a glairy fluid, or synovia, as it is called, which is

intended to lubricate the cartilages, and make the movements on each other as easy as possible. You will now see how important it is, that every joint should have a capsular ligament, because the synovia is thus prevented from escaping, which it must necessarily do, unless for such a bag as is thus afforded to it.

CHARLES.

What a beautiful provision this is! a sort of natural oiling, which is continually keeping the joints in a fit state for movement. The inventor of the patent axle-tree must have had this natural process in view, in devising his plan for preventing the necessity of frequently greasing the wheels of carriages.

DR. A.

Not improbably: but nature here does what art cannot effect; for she not only produces the fluid necessary for lubrication, but keeps it, by means of processes with which you will afterwards become acquainted, in a state of continual adaptation for its purpose.

I have mentioned that the shoulder-joint is lodged in a very shallow cavity, in order to allow of great freedom of motion. It is thus, however, more readily displaced; but the liability to injury which this circumstance, as well as its superficial position, produces, is a good deal diminished, by its being defended by projections of bone from the shoulder-

blade, as well as by a great thickness of muscle on its upper and fore part.

The elbow is a joint of a different character; and it resembles what is termed the hinge, in carpentry: the projecting parts of one limb, that which is called the fore arm, or lower arm, lodging into cavities made for its reception in the upper. The motion, like that of the common hinge, is only that of flexion and extension; and it has not only strong ligaments to bind the parts together, but is strongly guarded, as indeed many other joints are, by projecting bones, which are intended to ward off injury.

HARRIET.

The wrist seems to have a very extensive power of motion; but you do not mention it as having the ball and socket joint, like the shoulder, which I should have supposed it would have, in order to possess similar freedom of motion.

DR. A.

I have said that the shoulder is very easily displaced, a circumstance which, if it applied to the wrist, would deprive it of much of its utility; and nature has therefore employed a very beautiful contrivance, to combine latitude of motion with security. The fore-arm consists of two bones, the *radius* [Pl. I. No. 22. and Pl. II. No. 20.] and *ulna.* [Pl. I. No. 23. and Pl. II. No. 21.] These are fixed to the wrist or carpus, [Pl. I. No. 24. and Pl. II.

No. 22.] which, with the bones continuous with the fingers, and called metacarpal bones, form the hand. The articulation is of such a kind as to have the motion of the hinge, that is, to work upwards and downwards. This is effected by the hinge-joint; but in addition to this, there is a second and separate joint, for the purpose of admitting what is termed pronation and supination, that is, of allowing the wrist to turn round to a certain extent on each side, upon its axis, in order to raise or depress the palm of the hand. To effect this, the radius moves, laterally, on a little knob-like head of the ulna, and carries the hand round with it. But in order to facilitate the movement, it has likewise a certain motion of a similar kind, but in an opposite direction, at the elbow, where a knob-like termination of the radius, moves in a little canal in the ulna. You may readily perceive both those motions, in yourselves, by a little attention; and will easily see, that by means of pronation and supination, and the double articulation which I have mentioned, the wrist has all the security of the hinge-joint, with much of the latitude of motion of the ball and socket.

CHARLES.

There is a contrivance not very dissimilar, in the frame of the telescope, where it is necessary to raise or depress the instrument, as well as to move it to one side or the other.

DR. A.

The objects are a good deal similar in both cases; but there is one particular joint in the body, where the analogy with the telescope-joints is exceedingly close. I mean that of the head upon the spine, where, by a very curious mechanism, we have the vertical and horizontal motions in a very complete manner.

I have already mentioned that the vertebral column is exceedingly solid, with a very small motion only, in any one point. It is composed of very irregular bones, joined together by strong ligaments, but with the projections so fixed into each other, as to prevent the possibility of dislocation. This is very wisely ordered, on account of the substance which the vertebral column is intended to protect, viz. the spinal marrow; for the bones are so fixed together, as to leave a cavity open from the head downwards, through which the spinal marrow passes; and it is clear that dislocation could not occur, without entirely destroying the marrow, and interrupting the functions depending upon it. The motion of each bone upon another is very small and obscure; but it is assisted by a cartilaginous sort of substance, which lies between each joint, and which, by yielding to the different movements of the back, renders the power of motion a little more extensive, and at the same time more gradual and equable. This substance is a very peculiar one, and is not

strictly similar to any other in the animal frame. While it is yielding in its nature, for the purpose of facilitating and increasing motion, it possesses so much elasticity, as immediately to resume its usual state of expansion, on the muscular force to which it has yielded being removed.

CHARLES.

But it is curious that with the power which it possesses of yielding so readily, it should not give way, over its whole substance, to the weight of the body, and thus gradually diminish the power of yielding, when motion is wanted.

DR. A.

And so it does: we are rather shorter in the evening than in the morning, from the continued compression of this intervertebral substance during the day; and if it were not for the recovery of its elasticity during repose, we should experience the inconvenience suggested by you. But to explain the point which led to these observations, the head moves up and down, by its having a hinge-joint at the upper vertebra of the neck, the atlas, as it is called. In order to accomplish the rolling motion, a perpendicular projection exists in the second bone of the back, which is, from its resemblance in shape and magnitude to a tooth, called the tooth-like process, and is fixed securely by a ligament to a little notch at the fore part of the atlas. The

head with the atlas attached to it, works upon this tooth-like process, and thus obtains all the necessary freedom of lateral, and rotatory motion. You can readily understand how the head moves up and down, because it is by the common hinge-like movement; but it is more difficult to comprehend the mode in which the action of the head upon the tooth-like process, which I have just mentioned, is effected. You may, however, conceive how this takes place, by holding the fore-finger of your right hand perpendicular, and grasping it with your left hand. In this case, it is clear, that the left hand, with the fore-finger grasped in it, can be moved round in all directions on the right; and this may be a rough example of the way, in which the head moves on the tooth-like process represented by the fore-finger.

The head and hand, therefore, possess a similar freedom of motion; but it is accomplished by different means, and both of them in a way best adapted to the circumstances of the particular joint.

HARRIET.

But does this little elevated portion of bone give a strength to the joint, sufficient to prevent displacement?

DR. A.

It is to be remarked that the resting is perpendicular, so that the bearing is not upon the tooth-

like process, but the body of the bone; and to guard against lateral motion, which would break, displace, or injure this process, there is not only a very firm ligament to keep it in its place, and prevent its pressing on the spinal marrow, but there are likewise strong and firm ligaments to bind together the second vertebra, out of which the tooth-like process grows, to the atlas. There is also a very firm protection given, from the thick and strong layer of muscles and tendons, which take their origin from the vertebral column, and accompany it all the way down the back.

SOPHIA.

I suppose that some parts of the vertebral column have more capacity of motion than others; for in tumblers, I have often been surprised, and even distressed, at the twistings of form which they are able to make.

DR. A.

The neck and loins have more power of motion than the back; but still there is very little motion in each joint; and what there is, is much augmented by the compression capable of being exercised on the intervertebral substance which I have just mentioned.

There is another joint, which I may mention to you, the knee, which exhibits an example of great pains and attention bestowed on imparting to it strength, and the power of resisting injuries.

The thigh consists of one bone only, as you may see by the sketch; but the leg consists of two, the tibia, a large one; [Pl. I. No. 35. and Pl. II. No. 32.] and the fibula, a small one, [Pl. I. No. 36. and Pl. II. No. 33.] lying on the outside of it. These two bones are fixed very firmly together, and they are joined to the thigh-bone, at the knee, in the manner of a hinge; but to this they are not only united at the sides, by very powerful ligaments, but likewise at the very ends of the bones, by strong cords placed crossways, in the middle of the joint. A single cord, of a similar description, exists also in the joint of the thigh. The knee, too, is guarded in the front by the knee-pan, or patella, [Pl. I. No. 34.] which is intended to protect the edges of the joint, from the injury to which, unless for this appendage, it would be liable.

I have already mentioned to you, that the radius and ulna unite with the carpus or wrist, which, with the metacarpal bones, form the hand. The tibia and fibula, in like manner, unite at their lower part, with the tarsus or ankle, and this, in conjunction with the metatarsal bones of the toes, forms the foot. But the wrist and ankle, instead of consisting each of one bone only, are formed of several bones, so irregular in their shape, and so firmly united to each other, as to make displacement exceedingly difficult. These bones are, however, attached to each other in such a manner, as to

allow a certain slight degree of motion, which is obviously of great importance, both in the foot and the hand.

As it is my principal intention to communicate to you a knowledge of principles, and of some of the more important facts to elucidate them, it is not necessary to go further into detail with regard to this part of our structure. I would, however, merely advert to two sets of bones, which form a very important part of the body; namely, those of the head, called the skull; and those of the hips, or the pelvis, as they are termed, from containing various important parts within them, as a bason.

The skull was originally formed of many distinct pieces, which became joined by sutures, or a kind of zig-zag work, which in time became as solid as any other part of the bone, from the bony matter, at the place of junction, becoming firmly united. The hips, likewise, were formed originally of various separate bones, which became in time firmly joined together, and capable of supporting the great weight which they are intended to bear. They are fixed to the lower part of the vertebral column behind, and to the lower extremities before, so as obviously to be the material instruments of sustaining the principal weight of the body.

The sutures form a very curious mode of union, and one which is evidently applicable, in a very

admirable manner, to the junction of the bones. If you can suppose a small saw laid flat upon thin pasteboard, and the pasteboard to be cut, according to the marks which the teeth of the saw will make by a slight pressure, you will then have a sort of dove-tail work, by which each divided portion will accurately fit into the other. This very much resembles the juncture by suture, and it is beautifully adapted to the union of very thin surfaces.

CHARLES.

The points of union are by this means evidently much increased; whereas, in broader surfaces, where a larger front is applied, such a plan would be superfluous. But is the number of bones of the skull arbitrary, or does it follow a certain uniform division?

DR. A.

These bones are, with occasional trifling differences, the same in all skulls; and they are designated by particular well known names. The bone in the front is called the frontal bone; [Pl. I. No. 1.] the two immediately behind, the parietal bones, from being supposed to defend the brain, as a paries, or wall [Pl. I. No. 2. Pl. II. No. 1.]; that at the back of the head, the occipital bone [Pl. II. No. 2.]; the two immediately over the ears, the temporal bones, [Pl. I. No. 3.] These bones are all of them joined by sutures, which have also certain designations. That which joins the frontal

bone to the parietal bones, is called the coronal suture; that which joins the two parietal bones together, the sagittal suture, from being placed as an arrow (*sagitta*) on the curved coronal suture; the suture placed between the parietal and the occipital bones, is termed the lambdoid suture, from its resemblance to the Greek letter lambda, λ; and those which join the temporal bones to the parietal, to the frontal, and to the occipital bones, are termed the squamous sutures, from overlapping each other as a scale, instead of being dovetailed like the others.

SOPHIA.

Why are the bones at the sides of the head called the temples? There is a common idea, that a blow on them is more dangerous than at any other part of the head: is this correct?

DR. A.

Temple is an abbreviation of temporal; and they were termed ossa temporum, or temporalia, from tempus, time, because grey hairs were supposed to make their appearance first at this place, and thus to imply, that the effects of time were becoming visible. I am not aware of greater danger attaching to a blow on this, than any other part of the head; except in as much as a fracture, or other injury here, would be likely to be more deep seated, and to be further removed, therefore, from the reach of appropriate treatment.

There are two other bones which form the lower and front part of the skull, which are of a very irregular shape; these are the sphænoidal bone, from a Greek word signifying wedge, being thought to be fixed in the skull as a wedge; and the ethmoidal, from a Greek word signifying sieve, this being in the front, and perforated variously, for many important purposes.

CHARLES.

I am very anxious to know what bone is, or rather how it is formed; for I recollect having heard of its being composed of phosphate of lime, though I am at a loss to know how this particular salt furnishes such a singular substance as we see bone consists of.

DR. A.

The original state of the body is that of a soft kind of jelly, which contains the rudiments of parts, and in time acquires solidity, and that peculiar form which particular parts are destined to assume. The bones themselves, hard and substantial as they appear, were originally nothing more than soft pulp, contained within a membranous covering, which gradually became harder, and, at the proper period, acquired solidity sufficient for all the purposes of life.

CHARLES.

Do you mean, then, that there were in bones

intermediate states of solidity up to that of perfect bone?

DR. A.

Certainly; for the most substantial bone was, between its original softness and eventual solidity, in a cartilaginous state.

CHARLES.

Then I suppose bone is nothing more than hardened cartilage, and cartilage, hardened jelly.

DR. A.

This was an idea very commonly entertained by physiologists at one time, but it is totally incorrect; for the formation of the original jelly, or soft material of the cartilage, and that of the bone, are all different processes of the animal economy, depending on different actions of the vascular system. To understand this, however, it will be necessary to give you a slight sketch of the vascular system, and of the operations depending upon it; for though it would be more systematic to speak of these things separately, yet it is my plan to endeavour to make every thing intelligible as I go on.

The vascular system is a general term applied to the vessels, or tubes, which circulate the blood through the body, and by means of which its growth and nourishment are provided for. These tubes are called blood-vessels, and consist of arteries and veins. The arteries derive their origin

from the heart, and carry the blood over every part of the body; the large tubes being divided into smaller and smaller ones, until they are so small as to be incapable of being seen. The minute extremities of arteries are united to the minute extremities of other vessels, called veins, and these becoming larger and larger, at last form very large tubes, which bring the blood back again to the heart, from whence it set out, to repeat the same process of circulation. Now, the blood is the particular fluid from which every part of the body is formed, however different may be its texture, nature, and appearance.

SOPHIA.

But do you really mean to say, that our skin, flesh, and bones, are all formed of blood?

DR. A.

Not exactly of blood, but from blood; for the blood supplied by the food which we take into the body, contains the elements of all the particular substances of which the body is composed; and from it, by means of a process called secretion, and which goes on in the very minute vessels of the body, the particular substances, whatever they may be, are formed. Thus much it was necessary to anticipate, in order to keep up with our subject.

The soft jelly, then, which I mention as being the rudiment of the bone, was originally thrown

out by minute vessels; but in the course of time, and according to the wants of the system, the same vessels secreted cartilage, and afterwards bony matter itself.

The bony matter is deposited in a sort of net-work; and hence the appearance of spaces, when you examine bones, which are accidentally exposed. The net-work appearance arises from the original configuration of the material on which the deposit takes place, and which consists of what is termed cellular membrane, or a net-work of a very fine membranous substance. This, it is important to know, is universally diffused over every part of the body; it not only separates various parts, as the skin from the muscles, and the muscles from each other, but there is no minute subdivision of a muscle, which does not exhibit cellular membrane between its fibres. By this sort of configuration, connection takes place between the most distant parts of the body; and hence the practice among butchers, of giving a plump appearance to meat, particularly veal, by distending this particular substance with air; which is often done, likewise, to facilitate the separation of the skin. The cellular membrane assumes various appearances and modifications, and forms the frame-work, as it were, of all the various structures of the human body. This, therefore, is the frame-work of the bones, and with it is always contained a portion of animal

jelly, both which boiling will dislodge, and thus the earthy matter be left untouched. On the other hand, the action of acids will remove the earth of bone, and leave the membranous and gelatinous parts behind.

CHARLES.

There must obviously be a great deal of soluble matter in bones, not only from the effects which boiling has in extracting a large quantity of nutriment from such substances, particularly when high temperature is employed, but from many animals being able to procure from them so much of their subsistence. But do the proportions between the substances of which bone consists vary at different periods?

DR. A.

The younger the person is, the greater is the quantity of jelly; and in old people there is a much larger proportion of ossific matter, and, as it were, much less succulence of structure than in the young. Some animals have their bones composed entirely of cartilage, as the shark, skate, sturgeon, and all those fishes which are called cartilaginous; while the bones of other fish, of reptiles, and of serpents, are more than usually flexible, from the great quantity of gelatinous, and the small quantity of solid matter which they contain.

Every bone has a thin covering belonging to it, which adheres closely, and is called the periosteum,

or substance lying upon the bone. Within this covering, the substance forming the future bone lies, whatever its shape may be; whether round, as bones generally are, or flat, as are those of the head and some other parts of the body.

The vessels which circulate the blood in the jelly or cartilage, are, as I have mentioned, the means by which the bone is secreted; and the operation goes on in different parts of the bone, at the same time. The body of the bone has this process going on separately from its ends or heads; and it is thus wisely determined, because the body of the bone is required to take up as little room as possible, in order that there may be space left upon it, for the solid masses of muscle by which it is to be covered. The extremities of each bone are required to be larger, for the purpose of their being more conveniently joined to each other; and they do not require the same consolidation as the centres, because it is clear that any mass of muscle would interfere with the motion of a joint. We shall afterwards find that nature has provided for this point.

HARRIET.

You have thus shown us how bone is formed; but the jelly, and subsequently the cartilage, which precede the deposit of the bone, must have formed a solid mass, and bones have usually cavities in them.

DR. A.

The original mass of cartilage, and of jelly which preceded it, were unquestionably solid, that is, without cavity, and were equally diffused in the meshes of the network, or cellular membrane, which I have noticed; but the bony matter is deposited in such a manner in the large bones, as to leave a cavity, which still contains the original network, into which a fatty substance is thrown, which is distinguished by the name of marrow. Some animals, it must however be observed, have no cavities in the centre of their bones, such as the whale tribe, skate, and turtles.

The formation of cylindrical bones takes place so as to give them as much strength as possible in the smallest space. If they were entirely solid, they would be unnecessarily heavy; and if the materials were brought into smaller bulk, they would be weaker, because the strength of a bone is in proportion to the distance at which its fibres are from its centre.

The ends of the bones are formed distinctly from the bodies, and are separated by a sort of gristle; but in adult age, the union between their parts becomes complete.

In flat bones, as those of the head, there is, instead of a cavity, a sort of loose space, or lattice work, called diplöe, or meditullium, answering to the cavity of cylindrical bones.

CHARLES.

When a limb is broken, there is, I suppose, a similar process begun and carried on, to that which occurs in the formation of bone originally.

DR. A.

Very much so. The wounded vessels pour out a soft material, which, in time, has bony matter deposited in it, to supply the injury; but there is generally some irregularity of surface in the produced part, because the repair does not take place in a way equal to the original fabric. The new bone is called callus, and it has no cavity formed in it, as in the old.

SOPHIA.

I have heard sometimes of people's legs or arms not uniting after being broken. How does this happen?

DR. A.

There is, in such cases, a defect in the power of secreting bone, generally from some want of energy in the constitution, as it happens sometimes in old people; but there is likewise a disease in children, rickets, in which there is less power, in the constitution, of producing ossific matter. In some persons, without apparent disease, there is a constitutional tendency of this kind, which I have seen, in some instances, to a remarkable extent. — But if there is sometimes a deficiency in the power of

secreting bone, there is sometimes an excess; and it is a curious circumstance, that there is no vessel in the body which may not, some time or other, produce bone. The deposit of bony matter, in this case, frequently takes place on the coats of arteries themselves; and, in many instances, particularly when such a circumstance occurs in vessels near the heart, is productive of serious symptoms.

CHARLES.

I suppose the marrow is intended to transude through the substance of the bone, and keep it soft.

DR. A.

This was an old, but a very incorrect idea; for the vesicles in which the marrow is contained, will not, in their natural state, admit of any transudation. The marrow seems to have little more use than that of filling up, by a light substance, spaces, which it was important should not be filled with more solid matter. But it is to be observed, that it is not every animal which has marrow in its bones. In birds, the bones are almost all of them hollow, as you may see in giblets, but empty; that is, they are full of air, which enters them from the lungs, and thus adds to their buoyancy.

HARRIET.

There are two points relative to bones, which I cannot understand perfectly. I see how the found-

ation of a bone is laid, and how the bony matter is deposited; by which means it may be readily understood how a bone is formed of a certain size: but these bones increase, and I do not see what provision is made for this circumstance, since one can hardly conceive any thing like a process of stretching a bone, and at the same time adding to its bulk. The other point is, that, if the cartilaginous matter is deposited on the gelatinous, and the bony upon the cartilaginous, bones ought to consist of a mixture of all three substances; whereas in full grown bones, the whole is exceedingly solid, and exhibits little or nothing of either of the two first materials.

DR. A.

These are very natural observations; and in explaining the difficulties which you mention, I shall have an opportunity of noticing a very beautiful and important process in the animal economy.

I have already stated to you generally, that the body is supported by circulating vessels, which carry blood over every part of the body, and bring it back to the heart. Together with blood-vessels, there are also vessels which are termed *absorbents*, from their powers of absorbing, or taking up; and by means of their action, a continual removal of parts takes place, which have been formed by the operations of the circulating and secreting systems. These absorbent vessels arise in every part of the

body; and by the operation which they exercise on the one hand, owing to which the most solid parts are continually taken up, and by the agency of the secreting vessels on the other, which are continually depositing from the blood, and more remotely from food taken into the body, the substances of which the various organs consist, there is a continual process, uninterruptedly going on, of renovation and change of parts; by means of which nature not only provides for the proper materials of animal structure, but for their being kept in a state of health and vigour.

To apply these remarks to your first observation; the soft jelly, which formed the rudiment of the bones, is in time taken up by the absorbents, and is succeeded by cartilage, which, in its turn, is removed, and bone deposited: but though I mention the changes from jelly to cartilage, and from cartilage to bone, as gradual, yet it is to be remarked, that there is no period at which the absorbents are not at work, and removing the old materials, while the secreting vessels are renewing them, so as to keep the whole machine in continual order. Nature is thus in constant activity, and in constant change.

CHARLES.

This is really very wonderful; but does it not seem to be rather an unnecessary process, to build up, as it were, for the mere purpose of pulling

down; just as if an architect, after finishing a building, should set to work, curiously to remove stone after stone, with no other apparent view, than to supply, with the same material, the part which may have been removed?

DR. A.

The works of the architect, owing to the perishable nature of his materials, are liable to be continually affected by weather, and all kinds of accidents from without. He is therefore under the necessity of frequently going into a system of regular repair, by renewing what is defective, strengthening what is weak, and taking down, in order to build up with additional firmness. But with nature, the operation of consolidation and repair are simultaneous; for the process of renewal goes on so nicely in the most inward recesses of the body, as to leave no part without a continual circulation of new matter, and therefore of renovated strength and vigour, as long as the period of vigour is intended to continue. Absorption likewise provides for the growth of the body; for if nourishment merely furnished support, parts could acquire no additional magnitude, but would remain of the same size that they had originally. As absorption and nourishment, however, go on together, there is a continual means of increase afforded, while the necessity of increase continues; and this process puts at

an infinite distance, every thing of human invention or power. If an architect wishes to enlarge a room or a house, he must make an actual augmentation of feet or inches to the work already existing; if a machine is to be increased in size, its various parts must be taken to pieces, augmented, and strengthened, before it can be fitted for the additional work which it is intended to perform. The operation in the mean time is stopped: but in the works of nature, there is no cessation, no period of halting, or shutting up for repair; every process is simultaneous, and thus are not only nourishment and growth provided for, but also the removal of every thing which may be injurious or inconvenient.

HARRIET.

The process is most beautiful, and it is difficult to conceive any thing in contrivance so exquisite; and yet how little do we dream of such a continual series of interesting operations going on in the body.

DR. A.

Such is the fact; and the same beauty, the same adaptation, the same general harmony of usefulness, is manifested over the whole animal creation.

Before we take leave of the bones, I would just remark, that there is a certain analogy of structure among all animals which have vertebræ, and therefore a skeleton; but, in some animals, the

bony structure is on the outside of the body, as in all the testaceous tribes, which are enclosed in one or more shells; as the oyster, snail, whelk, &c.; and also in the crustacea, which comprise the crab, lobster, shrimp, &c.

SOPHIA.

But can the bony covering, under such circumstances, answer the purpose of an origin and insertion to the muscles?

DR. A.

In some of the testaceous animals, as the oyster, muscle, cockle, &c., there are muscles by which the animal opens and shuts its shells, or rather shuts them, for the opening takes place by means of an elastic ligament, on the power being suspended by which they are shut. Others of the testacea with one shell, the univalves, such as snails, for example, have muscles so connected with their shells, as to give the animal the power of thrusting out its body from the shell, and drawing it in again.

In all such cases, the principal part of the muscular structure exists independently of the shell; which is to be principally viewed as a defence to the animal. So it is likewise with the crustaceous tribe; and, in both them and the testaceous, there is a power of renewal in case of injury, which, in the former, not only goes to the shell, but likewise to the limb itself.

SOPHIA.

What, have such animals the power of regaining their limbs if lost?

DR. A.

Many of them certainly have: and lobsters and crabs are sometimes, after thunder storms, found to be entirely without their claws, which require some time for reproduction. The jar communicated to the water, and perhaps terror on the part of the animal, have the singular effect of making these creatures throw off their claws. A great gun fired by a ship of war will likewise do the same; and hence a threat of this kind will often bring an imposing fisherman to reasonable terms. The effort seems to be voluntary, for some of the younger of these animals will drop their claws, on an attempt to take them, without actual contact. The limb is forced off, as Dr. Macculloch has shewn, during violent extension, by means of a curious mechanical structure, with a loud crack.— In both the testaceous and crustaceous animals, the vessels of the surface have the power of throwing out, or secreting, the matter of the shell. Crabs and lobsters lose their shells annually, and seek retirement till the new shell is sufficiently consolidated; as they are aware of their defenceless state at such times. The shell is originally soft and membranous, and gradually obtains its proper thickness and solidity.

CONVERSATION V.

OF THE MUSCLES.

DR. A.

I MENTIONED to you, that an important use of bones, is to afford a place of insertion for the m cles. These are the organs which are concer in motion; and they make up a very consider part of the mass of the body, particularly of extremities. They are composed of bundle fleshy fibres, bound together, and consisting smaller and smaller bundles of fibres, connec by cellular membrane, and separable into fibres far as they are capable of being divided, or of be perceived, either by the naked eye, or by glas This fibre has been thought, by some, to be cy drical, and to envelope a portion of pulp; w the nice microscopical observations of Bauer duce Sir Everard Home to suggest, that the mate fibre may be formed of a chain of globule the blood, (which I shall have occasion afterwa to mention to you,) cohering together by an att tion between them, which takes place only w they are deprived of colour. — Microscopic ob vations have likewise discovered a globular str ture in the cellular texture of the body.

SOPHIA.

I recollect the surprise which I felt, in our first conversation, at being informed by you that all the flesh of the animal body consists of muscle: but in what way are the different actions produced by muscles; for flesh, whenever I have happened to see it, (though I must own I have not very attentively observed it,) seems to consist entirely of one mass of uniform material?

DR. A.

If, however, you should remark more particularly than you have yet done, some of the joints which come to table, especially the round of beef, you will see that there are different divisions, having different appearances, and, with gourmands, varied degrees of excellence. These are different muscles of the animal, with the fibres cut transversely, which are prolonged to the particular parts which they are intended to move. — The action of a muscle consists in its shortening itself, and thus bringing the parts to which it is attached nearer to each other. This is called its state of contraction; and when it resumes its original state, it is said to be in a state of relaxation.

SOPHIA.

In shortening itself, a muscle, I suppose, swells up in the middle.

DR. A.

It swells up in the middle, and becomes rigid over its whole extent; but it does not occupy more space in the whole than it did before. If you bend your arm firmly, you will find a large and rigid muscle, occupying the front of the arm nearly to the bend of the elbow; and if you shut the jaws forcibly, you will feel a rigid contraction extending forwards from the angle of the jaw. In the one case, the biceps or bender of the fore-arm is felt; in the other, the masseter, or principal muscle employed in mastication.

CHARLES.

One can feel these actions very distinctly; but I observe that the lower part of the muscle of the arm, which you have just mentioned, terminates in a hard sort of cord, which may be felt extending itself to the upper part of the fore-arm.

DR. A.

This is called a tendon, or sinew; and it is fixed to the part to which you can trace it in the fore-arm. On the other hand, the upper part of the muscle is traceable to another tendon, or rather two tendons, which are implanted at the shoulder, and give the term of biceps, or double-headed, to this particular muscle.

CHARLES.

It is clear that, considering the position of these

muscles, a shortening of the biceps will bend the elbow joint, and a shortening of the masseter will shut the jaw; and I should think, by knowing the origin and insertion of muscles, that it will always be easy to determine their use.

DR. A.

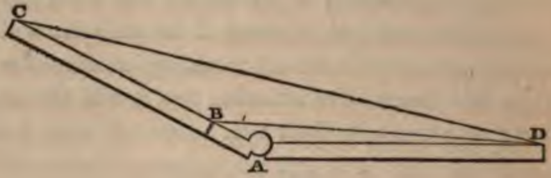
In a very considerable degree.

HARRIET.

I wish you could give us some little mechanical illustration of the action which you describe. I am not quite certain that I altogether understand it.

DR. A.

I think I shall be able to make it intelligible by means of a common two-foot rule, having a joint in the middle. If you suppose a rule of this kind to indicate the arm, fore-arm, and elbow, and I fix a piece of cord (at B) about two inches from the point (A), and bring it by the hand to a position (D), which we may suppose the shoulder, then it is clear that, if I draw the cord, I shall double up the rule, either wholly or in part, and thus imitate the action of bending the arm at the elbow. The cord here acts the part of a muscle; and must be drawn, just as much, in order to produce the effect of bending the joint, as the muscle must be shortened or contracted, in the bending action of the arm.



CHARLES.

It is exactly as you state; but yet with what a very little power the muscle thus circumstanced will act, when it is fixed so near the centre of motion. One would imagine that it was always an object with nature, to make the most of power; and to adopt the plan by which the greatest power would be most easily exercised.

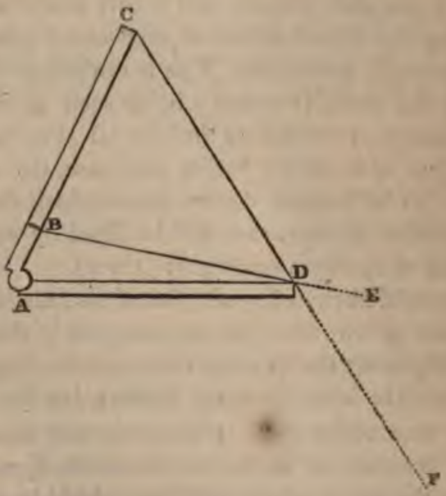
DR. A.

You are quite right in your conclusion, that there is a considerable loss of power by such a distribution of muscle as that which I have now noticed; and in works of human invention, the artist would aim at applying the power, at the greatest possible distance from the fulcrum, or centre of motion, in order to increase the effect. But then you must remark, that nature not only keeps in view the end required in her operations, but the most convenient method of arriving at it. Symmetry of form, the not taking up unnecessary room, facility of executing movements, all require that the parts concerned in motion should be as compact as

possible; and though there is necessarily a loss of mechanical power, in combining these advantages, yet nature has given to every muscle, power sufficient to execute what is required of it, independently of the loss which is thus sustained. If, instead of fixing the cord at two inches from the joint of the rule, we fix it at the extremity (C), it is clear that we shall act with greater power in bending the joint; but then, if we consider the cord as a muscle, there would have been a structure more like a large web, than a compact muscle, had nature aimed at employing the utmost extent of mechanical power in her muscular operations. This is obvious on shortening the cords (B D and C D) to such an extent, for example, as to double the joint (at A) in the way that you now see it; for, in this case, the whole space (A C D) between the two bones which the rule is intended to represent, will be filled by muscle, instead of merely a small part (A B D).

It would likewise happen, that if the muscle were inserted at, or near the extremity (C) of the rule, not only must the quantity of muscle be larger, to produce the same quantity of effect, but the muscular contraction must be much greater than if it were inserted (at B) nearer the centre of motion. Thus the length of the cord (B D) would be longer in the expanded rule than in the doubled one, by the length of the superfluous portion (D E); but then, if the insertion were at or near the extremity

(C), it is clear that the line (D F) which remains, after the same degree of contraction is produced as in the former case, would not only be much greater in itself, but would be much greater in proportion to the respective length of the muscles, than if the insertion had been at B. For instance, a contraction equal to D E, or about one fifth of the supposed original muscle (B D), will produce the same effect as a contraction equal to D F, or two thirds of the supposed original muscle (C D).

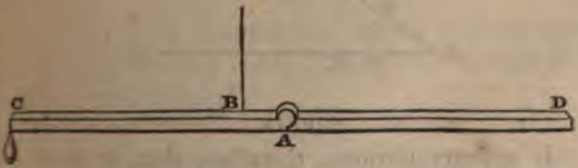


Nature, therefore, produces the same effect with a smaller portion of muscle, and a smaller portion

of muscular contraction, than would otherwise be necessary; though more power is required to compensate for the disadvantage under which it acts. But perhaps you will point out to us, Charles, the precise difference of power necessary when a muscle acts near, or at a distance from, the centre of motion.

CHARLES.

If the centre of motion is at A, the power at B, 2 inches from it, and the weight 5lbs. at C, at a distance of 12 inches from the centre of motion (taking the proportions of your rule as a diagram), then the power necessary at B, to raise the weight at C, is to the weight, as the distance (A C) of the weight from the fulcrum, is to the distance (A B) of the power from the fulcrum. The power at B must therefore be as the weight 5lbs. multiplied by the distance from the weight to the fulcrum, or 12 inches, which gives 60, to the weight multiplied by the distance from the power to the fulcrum, or 5lbs. by 2 inches, which gives 10; so that six times the power is necessary, when placed at B, to raise the weight at C, to what it would be if placed at C.



HARRIET.

Then, in fact, the power necessary is greater, the nearer it is to the centre of motion; and it would diminish, just in the proportion that the distance from the centre of motion increases.

CHARLES.

Certainly; and there is another mode of exemplifying the same thing. If, with the same letters, you suppose a power to act at B, then the same quantity of contraction which will bring B to E, will, in the same time, bring C to D: but the velocity must be as much greater as the distance A C is, compared with A B; or as the space passed through, C D, is to the smaller space B E. The space passed through, in a similar time, is therefore a measure of the velocity, and this of the power exercised to produce the effect.

SOPHIA.

It appears obvious, therefore, that it is the

object of nature to insure rapid movements, and to give an extraordinary degree of power for the purpose of effecting them, rather than to husband power, and take a longer time in producing the effect required.

DR. A.

This is, doubtless, the case; and there is no question, as Archdeacon Paley very properly observes, that, in what concerns the human body, it is of much more consequence to any man to be able to carry his hand to his head with due expedition, than it would be, to have the power of raising from the ground a heavier load, of two or three more hundred weight, for example, than he can lift at present. This last is a faculty which, on some extraordinary occasions, he may desire to possess; but the other is what he requires, and uses, every hour or minute.

CHARLES.

But is there not likewise a great loss of power in muscles, by their being inserted into bones at very small, and therefore unfavourable angles?

DR. A.

This is a circumstance which operates very strongly in every muscle, though much more so in some than others.

SOPHIA.

I wish, Charles, you would explain this point.

I am often puzzled in the application of reasoning about the magnitude of angles.

CHARLES.

If you wish to act with the greatest power, in raising or pulling any thing, you employ your force in a strait line from the object, that is at right angles to it, as in raising one end, B, of the bar A B, where the force exercised at B, in the direction B C, is evidently employed at a right angle. Now, if you alter the direction of the force employed, progressively, to D B, E B, and F B, you will find that the force required on your part is continually augmenting, just as the angles D B A, E B A, and F B A, are diminishing; and at last, if you act in a straight line from A to B, you will produce no elevation in the end B at all.

SOPHIA.

I now see clearly, that at a very small angle, there would be a great difficulty in accomplishing the object.

DR. A.

And, of course, there is a greater allotment of power, for the purpose of overcoming the difficulty. But in order to place before you, very distinctly, the great additional force which is thus required, I shall mention the calculations made by Haller, one of the most distinguished physiologists that ever existed, of the force required to be exerted by the deltoid muscle of the arm, in order to raise a weight of 60 pounds at the elbow, reckoning that the arm weighs 5 pounds of this.

CHARLES.

Is this muscle so called, from its resemblance to the Greek letter delta?

DR. A.

It rises above the shoulder, and is implanted at the fore part of the arm, at an angle of 10 degrees, at about one third of the distance between the shoulder and the elbow. As its origin is broad, and it is contracted at its insertion, it was thought to resemble the letter delta (Δ), though reversed. You have seen that the force required to raise a weight, by the previous explanation, was in the proportion of the distance which the weight from

the fulcrum, bears to that of the power from the fulcrum.

HARRIET.

Yes, when the weight was 5 lbs. and the proportions as 12 to 2, or 6 times, then the difference of power exercised was 6 times greater, or as 60 near the fulcrum; whereas it would have been only 10, had it been applied at the place of the weight.

DR. A.

Take therefore the insertion of the deltoid muscle at one third of the distance between the shoulder and the elbow, the force exercised there, is three times the amount of what it would be, if inserted at the elbow.

HARRIET.

Certainly.

DR. A.

Three times 60 are 180, and therefore it is clear that the actual weight, as far as the muscle is concerned, becomes 180 lbs.—But this is not all, the insertion of the muscle at an angle of 10, instead of 90 degrees, takes off the purchase in the proportion, as mathematicians have calculated, which 173 bear to 1000. The augmented weight, or, what is the same thing, the increase of power necessary to raise it, amounts therefore to no less than

1058 lbs. instead of the original 60 lbs.—The loss of power, however, does not end here; for the tendon of the muscle is never directly continuous with the fleshy fibres; and here then is a loss of power, in the proportion of the obliquity of the junction of these fibres to the tendon. This will be clear to you, when you consider, that if you wished to draw any thing to you, through the medium of a bar or stick, you would do so by means of a straight, not a crooked one. Hence, in the deltoid muscle, there would be a further loss of power of 228 lbs., which would augment the muscular energy required by it, to 1284 lbs.

SOPHIA.

What an immense exertion of force is thus demanded, and yet we are not at all sensible of any inconvenience from its exercise. Such power nature has bestowed on this part of our frame.

DR. A.

But, besides all the points which I have mentioned, there is another circumstance which we are to take into account, in considering the action of muscles; and this is, that action and re-action, in mechanics, are equal, and therefore that as much power is expended in resisting the bone, which affords a fixed point at one end, as there is in elevating the weight at the other; and hence the

last amount of the calculation, or 1284 lbs. is to be doubled, or made 2568, in order to come to a correct view of the force exercised by the deltoid muscles in raising 60 lbs. at the elbow.

SOPHIA.

I hope you have now got to an end, for the power of the deltoid, like the prowess of Sir John Falstaff, seems to go on increasing at every step.

DR. A.

But physiology beats him; for his two men in buckram increased but to eleven; while our original 60 lbs. have grown up to 2568 lbs. — In the animal body, there are various muscles which combine their actions for some particular purposes; but then a certain degree of the force of each is lost, because the operation is rendered less direct.— It likewise frequently happens, that particular muscles have their fibres disposed obliquely; and this will readily appear to you, from what I have already said, to be a saving of extent of contraction, by a larger expenditure of power. When nature had an important object to accomplish, loss of power does not appear to have been at all regarded in the construction of our frame; but at the same time, no opportunity was lost, to augment the mechanical power of muscles, when this could be done without inconvenience. The increased magnitude of the heads of bones; the

projecting processes of various bones, particularly those of the thigh and heel; the bones placed as appendages to some others, as the patella, or knee-pan, and the sesamoid bones, which are placed at the fingers and thumb; all of them afford opportunities for an increase of the angle under which muscles act, and therefore for an augmentation of their powers. To this I may add, as conducive to the same object, the smoothness of the cartilaginous surface of the joints, and the careful provision of a plentiful supply of synovia to lubricate them.

CHARLES.

Muscular contraction seems to be a thing which cannot be imitated; for while, in mechanical processes, cords or chains, when shortened, must be coiled up, or otherwise disposed of, a muscle simply contracts itself, and thus produces the necessary approximation of two parts together: but, considering the immense variety of motions which the different parts of our bodies are intended to perform, the number of muscles must be exceedingly great. Has this been ascertained with any correctness?

DR. A.

There are more than 500 muscles in the human body, all which are continually subservient to the purposes of motion, and are ready to carry into effect our will, in whatever way we may wish to

exercise it. It would be foreign to my object to give you any account of the names, origin, and uses of the muscles generally, which is a subject requiring much study and attention; but it will be satisfactory for you to be told of the number and distribution of those which are necessary for performing the motions, for example, of the arm and fingers; and they will give you an idea of the immense provision which the animal frame possesses in this part of its economy.

There are seven muscles which are principally employed in raising the arm at the shoulder joint, in different directions, and with different degrees of obliquity; and five in depressing it, of which two, which are of great strength, are felt at the armpit, from their being inserted at some distance from the head of the bone, in order to increase their power, particularly when a severe blow is to be given, as by a hammer. These muscles form the flesh round the shoulder joint, part of that on the side, back, and breast, and the greater portion of what covers the shoulder blade.

The fore-arm is moved by four muscles, which form the mass of flesh between the shoulder and the elbow, and, being planted below the elbow joint, are employed in bending and extending it.

The mass of flesh covering the fore-arm consists of muscles, which are employed in turning the palm up or down, in bending and extending the

wrist, and in bending and extending the fingers and thumb. There are not less than 17 of these; and on the hand there are as many more, which form, principally, the fleshy part of the palm. So that for the purpose of effecting all the motions of the arm, hand, and fingers, the action of near 50 muscles is necessary; all of which are regular in their origin, course, and insertion; have all separate names, derived principally from their use; and are all capable of being pointed out by the anatomist.

HARRIET.

In what way are the different muscles kept distinct from each other, so as to be enabled to act separately, and without interference? One would suppose, that, from their great number, there would be some danger of this.

DR. A.

Muscles form bundles of flesh, of greater or smaller magnitude, separated from each other by cellular membrane, which allows them to move freely over each other.

HARRIET.

The cellular membrane seems to be a substance of very great importance; it is found every where.

DR. A.

I have already mentioned its general nature to you, in noticing the structure of the bones; but

two or three other particulars I may now point out. Its universal diffusion I have stated; for it is found, as well among the firmest muscles, as the finest membranes of the body, as, for example, those of the eye. To the communication of its cells, it is owing, that pitting is produced where water has been secreted into them, as is the case in a particular description of dropsy. This arises from the fluid being forced by the finger into contiguous cells, from which, however, it soon returns, and fills up the indentation, or pit.

SOPHIA.

Then, I dare say, it is owing to the descent of the water, by its weight, that the legs of dropsical people swell, when they have been up some time, and fall on their assuming the recumbent posture.

DR. A.

You are quite right; and the use of a laced stocking, or a bandage, will, by giving support, prevent, to a certain degree, this effect from occurring.

CHARLES.

There would be this disadvantage, I should think, attaching to the general communication of the cells, that, in case of matter forming in any particular part, it would spread far beyond the place of its deposition.

DR. A.

This would, unquestionably, happen, except for a wise provision of nature, by which the same disorder which produces the collection of matter, namely, inflammation, occasions an adhesion, or sealing up of the cells around the collection or abscess, which circumscribes disease, and obviates the occurrence which you suggest.

CHARLES.

Is this adhesive effect of inflammation a general one, or is it merely adopted in this particular instance, for the purpose of preventing the diffusion of matter?

DR. A.

It is a general one, and, in fact, forms the principal means which nature employs to repair injuries; as is exemplified by the slightest cut. The part first bleeds; and after the vessels have contracted, so as to resist any further loss of blood, they throw out a lymph, which acts as a sort of glue, and binds the parts together. A certain degree of inflammation is always necessary for this operation, as you may know by the tenderness which occurs at the edge of a little wound, such as I now mention.

SOPHIA.

I have often observed this, and have sometimes interrupted the progress of healing, by accidentally

separating the edges which were half glued t
gether.

DR. A.

Inflammation is one of the most frequent, an
important diseases in the human body; and y
nature has employed it in effecting many saluta
operations. So ingenious, and so simple are h
arrangements.

The cellular membrane is the substance in
which fat is thrown, whether under the skin or
other parts of the body; and it has been suppos
by some physiologists, that there is a particul
set of cells destined to receive this secretion, in
much as it does not escape, like water, when
opening is made in any particular cell; nor do
it pit, on pressure, as when there is a watery d
posit. — But to return to the muscles. When a
particular motion is performed, you may genera
feel the muscle producing it, as a hard sort
band, amid a mass of soft flesh. This you m
readily do, in the inside of the arm, when you ben
and in the outside of the arm, when you exte
the fingers.

CHARLES.

The contraction may be both felt and seen; a
as I suppose the same is the case in other pa
of the body, I should think that it would be e
ceedingly useful to the painter and sculptor,

have a correct knowledge of the muscles, in order to depict their action with sufficient accuracy.

DR. A.

Unquestionably; and hence the Royal Academy has a professor of anatomy, whose duty it is to teach so much of anatomy to the students, as is necessary for the practice of their art. The particular kind and degree of action is likewise pointed out, as well by drawings, as by the movements of muscular persons, who are directed to take particular attitudes, and make particular exertions.

HARRIET.

The various emotions of the mind produce a powerful influence upon the countenance; and this is, I suppose, through the medium of the different muscles of the face, whose peculiar positions and actions, I should imagine, it would be important for the artist to study.

DR. A.

Certainly; and as you and your sister are both something of artists, I shall show you, from Mr. Charles Bell's pleasing work on the Anatomy of Expression in Painting, a sketch of the muscles of the face, with his description of their names and modes of action, by which you will be able to see what varieties of expression they are capable of producing.

In this drawing, the integuments are supposed to

be removed, and the muscles separated from each other below it.

HARRIET.

What a great number there is of these muscles, and how variously they seem to be entangled with each other. Have these muscles particular designations?

DR. A.

They have, as I shall immediately point out to you by a reference to the letters affixed to the sketch.

The uppermost muscle, A A, is the frontal; which is, in fact, part of a larger one, called the occipito-frontal, that has a portion on the back of the head, and another, the frontal, on the fore-

head: B B, is the knitter of the eyebrow (corrugator supercilii); and C C, the circular muscle of the eyelids (orbicularis palpebrarum).

The action of the fore and back part of the occipito-frontal muscle, is that by which some people are able to move the scalp to a great extent, and even to throw off the hat. The contraction of the eyebrows is principally effected by the action of the corrugator supercilii; and the shutting of the upper eyelid (for the lower one does not take a part in this case) is by the action of the circular muscle. In some complaints, and in drunkenness, the eyebrows are unequally elevated; and Hogarth has made an admirable use of this circumstance in many of his pieces, in depicting the countenance of a drunken man.

D, is termed the elevator of the upper lip and nostril;

E, the compressor of the nostril (compressor naris);

F, the elevator of the upper lip;

G, the elevator of the angle of the mouth;

H, the zygomatic muscle, which assists the last.

These muscles, with the exception of the compressor of the nose, raise the mouth, make the cheek full, and give an air of cheerfulness.

K is the circular muscle of the lips;

L, the depressor of the nostril;

M, the nasal muscle of the upper lip;

N, the triangular, or depressor of the angle of the mouth;

O, the depressor of the lower lip;

P, the elevator of the chin.

Expression of countenance, it may be observed, depends very much on the eyebrows, and angles of the mouth, and on the various motions made in these parts, by the muscles which I have just mentioned.

Q is the buccinator, or blower. It draws the angle of the mouth directly backwards, and contracts the cheeks when they are distended with air.

R is a thin web of muscular fibres, called platysma myoides, or broad muscle, which covers the side of the neck, and expands over the face. The part which passes forward to the angle of the mouth has been called risorius, or the muscle of laughter.

S is the last on the plate, and is termed the temporal muscle.

CHARLES.

The varied action of these muscles produces, then, I suppose, all the variety of expression of which the human countenance is capable; and in proportion as one set of passions, or another, predominate in the human character, something of a permanence of appearance may be communicated. This, I should imagine, must be the only proper foundation of physiognomy.

DR. A.

So I should think ; but Lavater, the celebrated physiognomist, in devising his system (if it can be called such), seems to view the different features, as possessing an original character from nature, which it only requires attentive observation to discover.

As you, Harriet, have made some advancement in the drawing of figures, you will find an advantage in studying, with your mother, some of the masterly delineations of the passions which are given in Mr. Bell's work ; but it may be advantageous and interesting to all of you, that I should now point out, by a reference to the sketch, some of the characteristics of the principal passions.

Rage is distinguished by unsteadiness of features; by the rolling and glaring eye; by the action of the muscles of the forehead, which alternately knits them, and raises them in furrows; the inflation of the nostrils; the swelling and expansion of the lips; and, in fact, by a violent and irregular action of almost all the muscles of the face.

HARRIET.

In brutes it seems to be principally the glare of the eyes, and the exposure of the teeth, which give the appearance of ferocity which they exhibit in this passion.

DR. A.

This is the case very much with animals of the

dog and cat kind; and the exposure of the teeth depends on the action of the muscles, called snarling muscles, which go from the margin of the orbit of the eye, and are inserted into the upper lip: but the lips have no regular circular muscle for contracting them, as in man; and they therefore hang loose, and relaxed, unless when they are contracted by the snarling muscles. Some of the more ferocious of the carnivorous tribe, as the lion and tiger, owe the peculiar glare and fierceness of the eye, Mr. Bell tells us, to the contraction of three muscles which are peculiar to them, and which, being fixed in the eyelids, draw them back on the prominent eyeball, and these produce the fixed straining of the eye; while, by stretching the coats, they give a greater brilliancy to the reflection from them. We shall afterwards find, when on the subject of the eye, that there is a peculiarity in the organ, which is another cause of the glare which the eye possesses in animals of the cat kind.—Graminivorous animals do not exhibit rage in this ferocious way; but principally by effects on the general system. Their eyes glisten, their nostrils swell, and they prepare their bodies for offence; but they are without the power of raising the lips, as in snarling, though they can do so, in such a way as to be allowed to feed; but for this particular action, they are provided with a

muscle which is at the front, instead of the sides of the mouth.

CHARLES.

Man seems to possess some of the attributes of the carnivorous race, in his indications of rage; for the lips are forcibly drawn upwards, in a manner somewhat similar to that of the more ferocious animals: but I suppose that, in them, the nature of their covering prevents the other indications of rage from exhibiting themselves, which are so marked in the human countenance, when acted on by this passion.

DR. A.

This must be in some measure the case; but it is likewise to be observed, that in man, there is a union of all the capacities for expression which belong to quadrupeds; and also several peculiar muscles, which seem to act as organs of expression, and to be capable of indicating emotions and sympathies, of which the lower animals are not susceptible. The knitter of the eyebrow is one of those peculiar muscles; and in its contraction, during rage, there is a mingling of mind and sentiment, with mere animal feeling, which distinguishes, in some degree, the ferocity of a man, from that of a brute.

SOPHIA.

I suppose, then, that if a dog's face, or that of any other animal, were dissected, like the human, of which you have shown us a sketch, the muscles would be found much less numerous.

DR. A.

Certainly; and the difference is very well exemplified by a drawing which Mr. Bell gives of the muscles of a dog's face, of which I now show you a sketch; and you will see, on comparing it with the sketch of the muscles of the human face, what a paucity there is in the former, compared to the latter; and what little variety of feature the one is capable of exhibiting, to the other, if even there were not the covering which Charles supposed likely to prevent small contractions of muscles from being discernible.

In this sketch, A A are the circular fibres, which surround the eyelids, and are common to all animals.

B C D are accessory muscles, called by Mr. Bell scintillantes, or glistening, which draw back the eyelids upon the eyeball, and give a sparkling fierceness to the eye.

F G H are muscles of the ear, which, in many animals, are well adapted to vary its direction, and

give it the necessary tension, to receive the vibrations of sound.

I K form, with the layer of muscles immediately below, the snarling muscles, as Mr. Bell terms them, whose action raises up that part of the upper lip from which the whiskers grow, and which is opposite to the canine teeth, and produces the peculiar, and well-known expression of displeasure in the carnivorous animal.

L is the muscle moving the nostril in smelling.

M, the muscular fibres of the mouth, which do not, as in man, make a perfect orbicular muscle; and the lips, therefore, unless when acted upon by the snarling muscles, hang loose and relaxed.

N, a muscle which retracts the angle of the mouth, and is useful in mastication.

O, a cutaneous muscle, which sends up fibres from the neck to the side of the face.

In the horse, it may be observed, there are muscles which raise the upper lip, and draw down the lower, at their middle, so as to uncover and protrude the fore teeth in feeding or biting. This animal has also muscles which draw the eye backwards, so as to increase his field of vision in that direction. The other graminivorous animals have a similar disposition of muscles in the lips.

Having given you this general description of the muscles of a dog's face, to enable you to compare them with those of the human countenance, I shall go on with the sketch which I was giving you of the peculiar designations of the passions.

The character of *suspicion* is a rigid contraction of the eyebrows and muscles of the face, as if under extreme attention; and a timorous side look of the eyes. *Discontent* is remarkable for the contracted forehead, the arched nose, and the depressed angle of the mouth. This last is dependent on muscles which are peculiar to man, and are called the triangular, or the depressors of the angles of the mouth; which give a very peculiar expression to the features, such as is not discovered in any other animal, in contempt, hatred, pride, and jealousy.

The effects of *fear* are to relax the energies of mind and body: the eyebrows are elevated, the eyes largely uncovered and staring, the mouth opened, and the breath spasmodically affected. There is a trembling in the cheek, lips, and muscles at the side of the neck; the countenance is pale, from the receding of the blood, and the hair rises, from the contraction of the skin.

CHARLES.

It appears that the effects of ordinary fear and rage are as nearly as possible opposed to each other, not only in their nature, but their physical effects; for while the latter excites, the former depresses every energy to the utmost extent. The elevation of the eyebrows, instead of their contraction, must produce a remarkable difference between the expression of the one and of the other.

DR. A.

In *smiling* and *laughing*, the circular muscle of the lips is relaxed; but in laughing, there is conjoined, an action of the elevating muscles of the cheek, which draw the angles of the mouth upwards and backwards, and accumulate, as Mr. Bell terms it, the cheek upon the eye; the mouth is open, the eyes half closed; the nostrils are dilated; and in a hearty laugh, the eyes are suffused with tears. There is, at the same time, a convulsive state of the respiratory organs, which, every

one knows, is sometimes to an inconvenient, and uncomfortable extent.

SOPHIA.

But how does it happen that we cannot help shedding tears in a hearty laugh?

DR. A.

Because the action of the muscles of the face raises the cheek against the eye, while the circular muscle of the eyelid is brought into action, and presses on the eyeball and on the little gland, called the lachrymal gland, which I shall afterwards have occasion to mention to you, as secreting the tears.

Conjoined with the action of the circular muscle of the eyelid, is that of the occipito-frontal, which unites with the former in giving an acute arch to the eyebrow. — The action of the depressors of the angles of the mouth converts a smile, or a laugh, into a sneer. — In *crying*, there is a sort of convulsive action in the muscles about the eyes. The cheek is raised, the nostril drawn up, the mouth stretched laterally, and its corners rather depressed, while the eyebrows are drawn down. There is likewise a convulsive action in the organs of respiration, which is very peculiar.

CHARLES.

The production of tears does not, I suppose,

arise from the same cause in crying and laughing; namely, from pressure on the lachrymal gland.

DR. A.

The shedding of tears in weeping, is always preceded by a pungent sensation in the membrane of the nose, which seems to excite a sympathy, not very well understood, on the lachrymal gland; and hence we find, that though the features may be commanded, the tears, under certain circumstances, will not be controlled. We must, however, defer the prosecution of this subject till our next meeting.

CONVERSATION VI.

THE MUSCLES CONTINUED.

SOPHIA.

You mentioned, at our last meeting, that there are some particular organs of expression peculiar to man, and to which there is nothing of resemblance in brutes. Is there any thing like laughing or crying among any other but the human race?

DR. A.

These indications of joy and grief are wanting in animals, for they have not the muscles on which they depend. They will testify joy and sorrow by some demonstrations of their own; but they are without the means of producing that variety and change of features, on which so much of the dignity of the human countenance depends. The orbicular muscle of the lips, and the muscles which are placed about the angle of the mouth, give a power of minute expression of feeling which is quite peculiar to mankind.

HARRIET.

But if there is not laughing, there seems at least to be crying among some of the brute creation;

for Thomson, in his description of the stag standing at bay, tells us, that

> The big round tears run down his dappled face.

DR. A.

The same is also mentioned as occurring in some other animals. For example, the phoca ursina, sea bear, or ursine seal, has been said to shed tears copiously, when wounded, or when its young have been taken from it. Pallas states, that when the Mongols find that the camel will not suckle its young, (which is very rarely the case) they excite the maternal feelings, and elicit copious tears from the old one, by employing a plaintive melody, imitating the voice of the young animal. Humboldt informs us, that a small American monkey is melted into tears on any fright or disquiet; and the keeper of the orang outang, brought from Batavia by Dr. Abel, assured Mr. Lawrence, as the latter gentleman tells us, that he had seen him weep a few times.— In all these instances (if quite correct), there is certainly more of the appearance of human sorrow, than usually occurs out of the pale of mankind; but yet it is to be observed, that all quadrupeds secrete tears, and may therefore have the flow of them increased under particular circumstances. The flow of tears, however, is, as you may recollect, only a part of the indication of sorrow; for it is the alteration of features which represents emo-

tion; and, this, with very little exception, and that applying principally to rage among a certain tribe of animals, as I have already mentioned, is entirely confined to the human race.

"This capacity of expression," says Mr. Bell, "this indication of a mind susceptible of great, or of tender emotions, has a great share in human beauty; whether in the living countenance, or in that which the pencil presents. How different the tame regularity of a merely placid countenance, from what strikes the spectator when he beholds the indications of a great mind in that susceptibility of emotion and energy, which marks the brow, and animates the eye of the hero, even in the calmest scenes of life! How fascinating, when compared with the insipid prettiness and regular features of an inanimate beauty, is that susceptibility, which lightens up the countenance, and plays upon the features of a woman of sensibility, even while she is unmoved by any particular affection!

"It is this emanation of the mind inspiring the features, and giving grace to the action, which produces the enchanting effect in painting. And if there be such a thing as pleasure arising from mere form, without expression and character, which I much doubt, it is a pleasure which must be very transient. In every possible condition and state of existence, there is a certain character to be

given to the body. It is alive, or dead; still, or in motion; it has the spirit and buoyant spring of youth, the massiness of manly strength, the grace and elegance of female beauty, or the cautious timidity and constrained motions and postures of old age, legibly impressed on the whole figure, and prescribing every motion and position of the body."

HARRIET.

The study of expression, as varied by the different emotions of the mind, seems, from the interesting details which you have given us on the subject, to be totally different from that of physiognomy; but I should be very curious to know on what leading circumstances Lavater depends, in forming his conclusions as to human character and capacity.

DR. A.

His work seems to be a series of observations hardly referable to any precise principle. He considers the bones of the head and face as the ultimate foundation of it, and as both giving to, and receiving from, the soft parts which are attached to them, a sort of permanent character and influence. He mentions, in great detail, and with numerous examples, the different appearances produced by various modifications of forehead, eyebrows, eyes, nose, lips, and chin; and recommends the study of silhouettes, or the profiles of countenances,

as giving every information which is necessary to the study of character, in a way superior even to the best portraits. He considers plaster models as much better than the countenance itself, for communicating an insight into the mind and disposition, because they can be viewed and studied in varicus ways, and measured and silhouetted in every direction; and he distinguishes, in silhouettes, nine horizontal sections, which I shall mention to you, as forming so many series of parts, to which the attention is to be given, in order to judge of character.

The first is the curve from the top of the head to the commencement of the hair at the forehead.

The second is the contour of the forehead to the eyebrow.

The third is the interval between the eyebrow and the root of the nose.

The fourth is the nose, to the commencement of the lip.

The fifth is the upper lip.

The sixth is the two lips taken together.

The seventh and eighth are the height and depression of the chin.

And the ninth is the neck, in which he includes the back of the head.

Every one of these parts, he enthusiastically tells us, "is a letter, a syllable, a word — often a decisive judgment, an entire discourse, on ever

truth speaking nature;" and he views, in his favourite object of contemplation, the profile, a positive and incontestable proof of the reality of the science of physiognomy, and one which, when the sections are in perfect harmony, affords such a decided insight into character, as to be distinctly read by a peasant, or a child.

After having given you so long an account of the effects of muscular action in communicating expression to the features, it is necessary to resume the examination of the general operation of muscles; and here I would observe, that a consideration of the motion to be performed, will generally show in what direction the muscles must lie, in order to perform it. Thus it is clear, that the muscles which bend, must lie in the fore part of the arm, and those which extend, on its back part; just as you may see that the rule, with which I have exemplified muscular action, must have its cord, which is to double it up, on the inside, and that which is to return it, or what is similar in effect, to extend it, on the outside.

SOPHIA.

One sees occasionally people with various workings in their face or limbs; are these from an action of muscles, which they are unable to prevent?

DR. A.

Certainly; muscles are subject to what are

called spasmodic affections, during which they contract, and perform certain actions independently of the will. Sometimes, too, only a few fibres of a muscle are affected; and then a sort of twitching is produced, which consists of alternate contractions and relaxations, and is rather uncomfortable.

HARRIET.

Cramps, I suppose, are of the same description, —violent contractions of the muscles.

DR. A.

They are so; but here the relaxation or cessation of action does not take place; and the continuance of the violent action becomes exceedingly painful.

HARRIET.

But I have seen persons where there has been a distortion of the countenance, as if from a permanent contraction; and yet there did not seem to be any cramp.

DR. A.

There was, in this case, a loss of power of the muscles of the opposite side, from palsy, most likely, by means of which the sound muscles, from there being no natural power on the opposite side to act against them, take a more contracted position than usual.

CHARLES.

Then it appears, that when the mouth is seen

drawn to one side, it is not the side in which the distortion is most manifest, which is the part affected, but the opposite one.

DR. A.

This is precisely the case; for all the actions which we perform, by means of certain muscles, over one side of the mouth, we can also perform, by means of corresponding muscles, on the other side of the mouth; and when neither sets of muscles are in action, they balance each other, so as to keep the mouth even. In the case of paralysis of the muscles of one side, the power of these muscles is lost, and the balance is destroyed. The same happens in various other parts of the body, as in the tongue and neck, where the muscles are disposed in pairs, and are said to be antagonists to each other. I may also remark, that whenever there is a muscle which moves a part in one direction, there is another muscle, or set of muscles, to restore it to its former state. For instance, if you bend the arm, you act with the flexor muscles to produce this effect; but, in order to bring it to its usual state, you act with the extensors, and gradually withdraw the action which bent the arm. A mere cessation of contractile power would leave the limb, where it was, to obey the mere operation of gravity upon it; but by this reciprocal operation, muscles act, as Dr. Paley very aptly states it,

like sawyers in a pit, by pulling at different times, in opposite directions.

SOPHIA.

But considering the great number of muscles which there every where is, there seems to be hardly space sufficient on the bones for their insertion; and near the joints, the muscle seems to cease.

DR. A.

Nature has adopted a very ingenious plan for diminishing the space necessary for the insertion of muscles, and this is, by the use of what I have already mentioned to you, as tendons, or sinews. These are a species of ropes, which occupy little space in their attachment to the bone, and therefore allow a free motion of the joint, and a greater symmetry than if the joints were covered with large masses of flesh. They are very strong, and are firmly attached to the muscles, which, at a certain distance from the joint, expand into a fleshy mass, so as to fill up the surface between one joint and another.

CHARLES.

Then I suppose the tendons are merely muscles more consolidated, so as to occupy less room.

DR. A.

Their nature is very different, tendons being principally composed of gelatine, while muscles

consist chiefly of fibrine, or the fibrous part of the blood, which I shall afterwards have occasion more particularly to notice. They have no power of contraction, and are therefore merely passive, following the impulse which the muscles give them, to which they are firmly attached, and capable of being separated from them by maceration, or boiling. Sometimes the tendons are of great length, as in the fingers; and you may observe that the back of the hand is covered with thin cords or tendons, which belong to the muscles that extend the fingers, and which lie on the outside of the arm. It is evident that in this case, the hand and fingers would have been much incommoded in their various and delicate motions, by a larger mass.— Every muscle is bound round or encircled by a membrane of cellular substance, called a sheath, which serves to give it additional protection, and also to preserve the muscles in their place; for the cellular membrane, as I have before observed, having a loose kind of union throughout, preserves the parts in their relative position, without at all impeding their motion upon each other.

CHARLES.

But as the muscles and tendons are in such continual motion over each other, is there any inconvenience from this friction, or any means employed to prevent it?

DR. A.

The muscles being of a soft nature, can move over each other glibly, and without difficulty; but it would be different with the hard cords which form the tendons; and therefore nature has wisely formed, whenever there is friction of tendons upon tendons, muscles, or bones, a small cavity, called a bursa mucosa, or mucous bag, of cellular membrane, which has a secretion poured into it, resembling the glairy liquor, or synovia of the joints, that facilitates motion, and prevents injury from friction or pressure.

HARRIET.

You mentioned that muscles have both an origin and insertion in bones; but how is it with the tongue, whose motions are so numerous, and where there is no bone to which its muscles can be attached?

DR. A.

I particularly spoke of motions where joints are concerned; but there are various other motions, to which muscles are subservient, in which the plan adopted in the limbs is not admissible. In the instance of the tongue, there is a bony attachment of muscle, only at the back part; while towards the point of the tongue, the muscles are curiously united to each other, so as to admit of every description of motion with the utmost facility. This

structure is necessary in the production of all the minute differences of action requisite to the formation of language; and in order still more to facilitate the movements of this active little organ, it is attached, behind, to a bone called the os hyoides, from its resemblance to the Greek letter υ, which is so fixed to the neighbouring parts as to admit of some degree of motion. This, it is obvious, must be of particular importance in the act of swallowing, when any unyielding body would be very much in the way. — But some muscles, it must be observed, are not attached to bones at all; for instance, the heart, which we shall find is one of the most powerful muscles of the body. The stomach and bowels, likewise, have a muscular structure, which is connected with the propulsion of the food.

HARRIET.

But I thought that muscles always obeyed the will; the motion of the heart, and other internal parts, is quite independent of any power of guidance.

DR. A.

Certainly; but all muscles are not obedient to the will; and hence they are divided into voluntary and involuntary muscles. For as there are certain functions, as those of motion, which must always be performed with consciousness, there are others

which must continually go on, and which nature has therefore wisely ordained to be quite independent of any thought or arrangement of our own. As examples of this, I may mention the action of the heart, in projecting the blood; and that of the stomach and bowels, in passing on the food which has been received into them.

HARRIET.

This is admirably managed; for I fear that if we had the guidance of all the functions of our bodies, we should be very apt, in our anxiety that some processes should go on well, to overlook others, and thus act much like a husbandman, who might have the winds and weather at his disposal. But this exertion of voluntary power over a muscle seems to be very surprising: we have only to will a particular action, and the action follows the thought.

DR. A.

This is really the case, and a most surprising phenomenon it is; for there is no perceptible interval between the willing to do a thing, and the completion. Our muscles, therefore, seem to be a set of obedient servants, placed in every part of our bodies to do our pleasure.

CHARLES.

But what sort of influence is that which is thus

exercised by us, and how is the power communicated?

DR. A.

These are questions which can be but very imperfectly answered, for they involve that inscrutable connection between the material and immaterial part of the animal body, which we know only by its effects. We are conscious of the exercise of will, and we see that action follows this exertion; but most of the intermediate steps are beyond human cognizance. Placed at a distance from all the muscles, the brain communicates an influence to them through the medium of the nerves, either directly, or by the intervention of the spinal marrow. If the connection between the brain and a muscle is cut off, as by an accidental division; or the energy of the nerve lessened, as in palsy, then the muscle has not the power to obey the will, or does so very imperfectly. Hence the nerves are the media by which the will acts upon the muscles; but how the nerves are acted upon by the immaterial, and consequently the nobler part of the animal constitution, is one of those arcana which the divine Creator has not permitted to be known to us.

The celerity of muscular action is very astonishing. It has been calculated that 1500 letters may, by very rapid communication, be pronounced in a

single minute; and if you consider, for an instant, the astonishingly rapid movements which the fingers are capable of making in writing, or in musical execution, you will be able to imagine, in how minute a portion of time muscular actions are performed.

SOPHIA.

Habit, however, I suppose, imparts a great facility in the exercise of such muscles; for it is very difficult to get the rapidity of movement which many performers on different instruments possess.

DR. A.

Movements have, in time, a certain association one with another, and this makes them appear to be in some measure independent of continued voluntary agency; but still the motions cease, as soon as the will to move is discontinued, and begin again when that is renewed. — The precision with which we can direct the motions of our limbs is extraordinary. We require no calculations, as the mechanist does, as to the power which we are to produce; for we at once do what we wish to do, and no more. This has been put in so striking a light by the late Dr. Barclay of Edinburgh, that I shall read you a passage on the subject, from his very excellent work on Muscular Motions. "Let us suppose," says he, "the circumference in which a bone can be moved to be 24 inches; that each

of the inches is equally divided into 12 parts; and that the bone may be assisted at each of the divisions, which we know to be possible; with what accuracy must the muscles contract towards the centres, in order to regulate their extent of motion with so much precision towards the circumference. In producing the several musical notes, by changes in the small aperture of the glottis," (which, by the by, is the opening from the mouth into the windpipe,) "or in balancing the body on the tight or slack ropes, we know that the muscles must contract with such minuteness and accuracy, as frequently to regulate their extent of decurtation, by smaller measurements than the 200,000th part of an inch."

SOPHIA.

This is very wonderful, and yet how little are the powers with which we are gifted, the daily operations of living beings, the subjects of remark, much less of the admiration which they are so well calculated to inspire.

DR. A.

The force which muscles are capable of exercising is very great. Three hundred pounds have been elevated by the muscles of the lower jaw; and when a person with a burden on his back, stands on tiptoe on one foot, the whole weight of the burden, and of the body, is borne by the extensor mus-

cles of the foot. — During action, the muscle itself seems to acquire a great addition of strength, and of power to resist injury; for a blow which would bruise the flesh very much, or break a bone, if received unexpectedly, and in a state of relaxation, can be received with impunity by muscles in a state of contraction. It is in this way that the feat of breaking a poker over the arm is explained; for the rigidity of the biceps muscle, which, as I have mentioned to you, lies immediately above the elbow, on the front of the arm, will, particularly if the power is increased by habit, receive, and repel, without injury, a very severe blow. — It is on the same principle, that Leather-Coat Jack, as he was called, who lived in the time of Dr. Hunter, was enabled to bear a carriage to pass over him, which he would do at any time for a very small recompense. After death, he was found to have very strong muscles, and large projections of bone, into which they were inserted, which gave him the faculty of very powerfully contracting his muscles, so as to resist the immense pressure which I have mentioned.

SOPHIA.

It seems to be upon the same principle that we can bear an impulse of any kind when we prepare for it, better than when it comes unawares.

DR. A.

Certainly. We oppose the contraction of muscles

against the impulse directed against us, and thus prevent the loss of equilibrium which would otherwise be inevitable.

HARRIET.

I have heard of experiments being made on the bodies of dead animals, by which movements were executed after death. How is this reconcilable with the doctrine of voluntary power, and of muscles being obedient to the will?

DR. A.

The muscles, during the state of life, have that kind of connection with the brain, by which, on the one hand, they are obedient to the will, and, on the other, communicate to the mind impressions made upon them. A certain structure, known by the name of muscular, is imparted to them for this purpose; and it is a property of this structure, on whatever circumstances it may ultimately depend, to contract when a stimulus is applied to it. If a portion of the scarf-skin were abraded, and the tender part touched by a pointed instrument, pain would necessarily be produced, but no muscular contraction. If, however, on the other hand, the abraded part were a muscle, you would see a contraction of the muscular fibres take place, or a species of convulsion. Now the same cause which produces this tendency during life, exists for some time afterwards; and is capable of being manifested,

more particularly by that modification of electricity, which is known by the name of Galvanism. — If, for example, in a dead frog, one extremity, with the skin taken off it, be placed on a piece of silver, and the other on a piece of zinc, and the two metals be brought into contact, convulsions are produced. The same happens, also, in any of the larger animals, when the Voltaic apparatus (in which the electric power is elicited, through the means of alternate pieces of zinc and copper, with a dilute acid interposed,) is made to complete a circle through any particular part of the body: at the instant of contact, convulsions are produced.

SOPHIA.

These must be very uncomfortable experiments. One shudders at the idea of involuntary motions; and cannot help fancying, that a portion of life and feeling must exist, when motion, the constant or usual accompaniment of life, is produced, under whatever circumstances it may occur.

DR. A.

The discovery of this particular mode of exciting muscular action, I must observe to you, though attributed to M. Galvani, was really due to his wife, who accidentally observed it when some frogs were lying on a table, ready prepared for making the soup which is so much used as a restorative in Italy, near an electric machine. While the ma-

chine was in action, one of the attendants happened to touch, with a scalpel, the crural nerve of one of the frogs, which was not far from the prime conductor, when it was remarked that the muscles of the limbs were thrown into strong convulsions. This experiment was performed in the absence of the Professor, but it was reported to him by his lady, who was much struck with it. M. Galvani repeated the experiment, varied it in different ways, and being engaged in a set of experiments, the object of which was to prove that muscular motion depends on electricity, he was induced, by this accidental discovery, to prosecute his inquiries with redoubled diligence.

The size of muscles, and the power which they possess, are very much connected with the quantity of their employment. The muscles of the legs in dancers; of the arms in blacksmiths; of the shoulders and back in porters; all of them obtain an increase of bulk, which still more fits them for the duties which they have to perform. In the lower animals, also, this is strongly exemplified; and whether they are principally accustomed to running, flying, or swimming, the muscles which are respectively used in these processes, acquire additional force and magnitude. In birds, there is a striking difference between the size of the breast-bone, and of the muscles implanted into it, in such as principally or occasionally support themselves on the

wing; and those, as the ostrich, or penguin, which employ the wings only as an aid to the feet. The muscular power of the wings may readily be conceived from the long flights which birds are capable of taking, and the short time in which they are performed. It is said that a pigeon will fly thirty miles in nine or ten minutes.

HARRIET.

Have people ever succeeded in adapting wings to their bodies, so as to support them at all in the air?

DR. A.

From the time of Icarus downwards, there have been many attempts; but they are quite absurd. All that can possibly be done is to imitate a sort of parachute, so as to diminish the celerity and force of a descent; for birds fly, as well by the size of their wings, as by the immense power of the muscles which move them, to which we have nothing in any degree similar. — Birds have likewise hollow bones, to make them more buoyant; and some of them (as we shall afterwards find) even pouches, which receive air from the lungs, in order still better to enable them to remain suspended in the air, or to float on the surface of water. The muscles of the breast of a bird are equal in weight to that of all the other muscles of the body put together; and it is clear, therefore, that, setting aside the other cir-

cumstances to increase buoyancy in which he is deficient, until man had a muscle of equal power, instead of the thin pectoral muscles which cover the side of his chest, and are inserted into his arm, he must be satisfied with something short of aërial flights. — The buoyancy which birds are capable of obtaining, through the means of hollow bones and air-bags, is strikingly evinced in the facility with which the majestic condor, the enormous vulture of the Andes, which is said to measure 14 feet with the wings extended, can suddenly dart, as Humboldt has seen him do, from the bottom of the deepest valleys, to a considerable height above the summit of Chimboraço, which has an altitude of 21,470 feet above the level of the sea. It is to be observed, however, that Humboldt must have been at a considerable elevation when this took place, and that this animal usually occupies situations of very considerable altitude; but still, when the rarity of the air is so great as it must be at the top of such elevated mountains, and which is indicated by the barometer being below 10 inches, the diminution of specific gravity, necessary to make so huge an animal be supported by air so highly rarefied, is wonderful.

CHARLES.

Is there any structure in fish, similar to that which is employed in increasing buoyancy in birds,

for the purpose of assisting them in swimming, or in their ascent or descent in the water?

DR. A.

There are air-cells in all fish which have the power of ascending or descending in the water; and such animals are able to compress their organs strongly, by means of appropriate muscles, so as to condense the air in the cells, or force some of it, as has even been supposed, into the stomach or gullet, from which it can escape from the body.

CHARLES.

I have never observed any thing like tendons in fish, as one sees in quadrupeds and birds; and I suppose they are unnecessary in them.

DR. A.

Their muscles are paler, and are of great force and magnitude; but as their motions are fewer, and as they have not limbs and joints, there is not the same occasion for arrangements to diminish bulk, at particular parts of the body. Their fins and tails are the organs by which they carry into effect their various powers of motion, through the medium of appropriate muscles.

I have already observed that there are many muscles in the human body which have no insertions in bones; bones are therefore by no means necessary to the existence of muscles, for there are

numerous animals which have no bones, as insects, worms, and the whole of those which are termed mollusca, which are capable of the most active and diversified movements, far beyond the proportion of what the higher orders of animals are capable of performing. The minuteness and number of the muscles which the bodies of the smaller animals possess, may be judged of from the account which Lyonnet gives of those of the caterpillar of the cossus. In the head, as Kirby and Spence inform us, he found 228; in the body, 1647; and enveloping the intestines, no less than 2186; which, after deducting 20, that are common to the gullet and head, gives a total of 4061. In the human subject only 529 have been counted; so that this minute animal has 3582 muscles more than the lord of the creation.—It is not, therefore, in the higher orders of animals that the beauties and the bounties of structure are alone discernible. The most minute insect exhibits a system of admirable provision and adaptation, just as much as the stupendous elephant, or even proud man himself.

HARRIET.

I have often been struck with the power which flies and insects have, of walking up perpendicular places, and even along ceilings, upside down. Is there any thing glutinous in their feet, which ena-

bles them to adhere so securely to a wall? But yet there seems to be nothing of a sticky nature left behind, that indicates such to be the case.

DR. A.

The circumstance which you mention is a very curious one, and was, for a long time, but little understood. It was not till Sir Everard Home had an opportunity of examining the Lacerta Gecko, a species of lizard, which is a native of Java, that any light was thrown on the subject. This animal was observed by Sir Jos. Banks to come out in an evening, from the roofs of the houses, and walk up and down, with perfect ease, the smooth, hard, polished Chinam walls, usual in that country, in search of flies, which are its common food. On examining the feet it was found, that this animal has five toes, at the end of four of which are sharp claws. At the lower surface of each toe, are sixteen transverse slits, leading to as many small cavities or pockets, with fringed edges; and connected with them is a curious structure of muscles, by means of which the edges of the pockets are turned down, and forcibly kept upon the surface on which the animal stands; while the muscles within, by their action, pull up the pockets, and produce a kind of vacuum which tends to keep the animal from falling.

CHARLES.

Then these little pockets may be considered in the light of suckers, which are acted upon by the will of the animal, so as to make a vacuum at pleasure, and thus by means of the pressure of the atmosphere, to render the animal adherent to any substance against gravity.

DR. A.

This is precisely the case; and Sir Everard found it to have a considerable analogy with what occurs in the echinus remora, or sucking-fish, which adheres to the bottoms of vessels. In flies and insects he found a structure exceedingly similar, a vacuum being formed, at pleasure, by means of suckers and appropriate muscles, attached to the lower part of the feet of the animal.

HARRIET.

How exceedingly curious and interesting this provision is, that the principle of the air-pump should be applied so extensively and so elegantly; but are there examples of a similar structure in larger animals?

DR. A.

The same plan has been found to be adopted in the hinder flippers or feet of the walrus, or sea-horse, which are made like gigantic webbed hands, and are furnished with muscles, which can raise

up the centre of the hand when laid flat, and thus make it act as a cupping-glass, to prevent the animal from falling back in its movements, whether on ice, or in climbing rocky cliffs. — Other animals use their claws in climbing, as cats; or their hands and feet, as monkeys; or their tails, as sapajous, a division of monkeys, and chamelions; while some birds, as woodpeckers, can support themselves against trees by the pressure of their tails, when they are employed in seeking their food in decayed trees, which furnish so many of the insects on which they live. — The form of the bodies of animals, and the disposition of their muscles, are adapted to the various motions which their greatly diversified modes of existence require; but you will hardly think that a particular structure is bestowed on some animals, for the purpose of giving them a facility of remaining stationary.

SOPHIA.

This would be very curious, for an animal is stationary when it does not employ its muscles.

DR. A.

And in most of the Mammalia class repose consists in the recumbent posture, when no muscles are employed; for you will observe that in standing, there is a continued action of the extensor muscles of all the joints; and that if this were to

cease, or be suspended from any cause, the animal would sink to the ground. — Some birds, however, have occasion to stand very long on one leg, as storks; and they, as well as perching birds, have a very curious conformation of limb, which I must mention to you, for the purpose of avoiding the necessity of long continued muscular action. The upper part of the stork's leg has a projecting piece of bone, which, when the leg is extended, is lodged in a sort of depression or socket in the lower part of the thigh, adapted to receiving it. It is obvious that by this mode, as the bearing is perpendicular, and as certain ligaments, like springs, keep the limbs together, they are in a state of attachment to each other, without the operation of muscles, and therefore without the fatigue of muscular exertion. The perching birds are able to maintain their hold of the branches of trees without constant attention, and to sleep in that posture. This they do by means of the tendons of the flexors or benders of the toes passing over the heels, and being so united to muscles arising near the upper part of the thigh, as to be acted upon, and thus to bend the toes, and make them grasp any particular twig, according to the pleasure of the animal, when the weight of the body, in perching, presses down the thighs and legs. At the same time the flexibility of the neck allows the head of the bird to be carried back

and placed under the wing, so as to bring the centre of gravity more over the feet, and therefore enable the bird to stand more steadily.

Before we take leave of the muscles, it is necessary that I should tell you something of the nature of muscular flesh, or fibre, as it is usually termed. — I have already stated to you, that the fibres of muscles are separated from each other by cellular membrane, a substance principally consisting of jelly or gelatine, the nature of which I pointed out to you, when we were on the subject of the integuments. Long continued boiling, or maceration in water, separates this jelly, and any other extraneous substance, and leaves the muscular fibre in nearly a pure state. We then find it to be a whitish, insipid, stringy substance, insoluble in water, and hardly at all putrescent. It is termed fibrine, and is considered as a species of condensed albumen. It is similar, as we shall afterwards find, to one of the most important component parts of the blood, and it has a material share in the nutriment of man, and of many other animals.

HARRIET.

It seems to be very remarkable, that a tasteless and insoluble part should be so important in nourishing the body. I should have thought that the boiling, which you speak of, would take every

portion of nourishment from the flesh which has been subjected to it.

DR. A.

I do not mean to say, that in the state to which it is brought by boiling or maceration, it would be well adapted for nourishment. At any rate it would not be an agreeable article of support: but in the form in which it exists as common flesh, its parts are so separated by the jelly, albumen, and other substances adhering to it, as to be more readily digested than it could be in its separate form.

HARRIET.

Then the particular flavour of animal food exists, I suppose, in the jelly which is obtained from the meat by boiling it.

DR. A.

If the broth is boiled down, so as to become a dry extract, and alcohol, or the strongest spirit, be poured on it, a portion of this extract is found to be dissolved, which is recovered on driving off the spirit. The part so recovered is what gives the particular flavour to meat, and has been termed osmazome. It is to be remarked, however, that fibrine, though insoluble in water, is soluble in some acids; and that, with nitric acid, it is converted into a very curious fatty substance, called adipocere, which has obtained a great deal of fame

in animal chemistry. The notice of this circumstance leads me to mention a very extraordinary spontaneous change which muscular fibre undergoes, when placed under certain peculiar circumstances.

At Paris there was a very large burying ground, called La Cimetière des Innocens, which had been, for a very long period, the receptacle of about 3000 bodies annually, which were buried in deep pits, containing layers of 1200 or 1500; and these covered over with earth, again and again, till there was an elevation much above the natural height of the soil. Complaints having been long made of the insalubrity of the air, by the continuance of this mode of inhumation, it was determined, in the year 1782, to remove the soil and its contents; and when this was set about, it was found that the corpses were not very offensive, and that every part, except the hair, bones, and nails, was converted into a sort of cheese-like substance, of a grey brown colour, not unlike spermaceti in texture. This change was effected by the putrefactive process going on in a confined place; and new combinations occurring, from the materials of which the body was composed, acting upon each other.—A similar change has been produced by the action of nitric acid upon muscles; and it is found, likewise, that if a piece of beef, or other animal substance, is exposed long in a running stream, it is converted

into a similar substance. The substance resembled very much that which I have mentioned, as being produced by the action of nitric acid on muscle.

These singular changes which can be effected in the state of the muscular fibre, gave to some gentlemen the hopes of being able to turn to use, and profit, the flesh of such animals as are not used as food, and are at present doomed to putrefaction; but the attempt has been long given up, on account of its having been found impracticable to purify the fatty mass sufficiently.

CONVERSATION VII.

OF THE BRAIN AND NERVOUS SYSTEM.

DR. A.

I HAVE already stated to you, that nerves are small white cords, of various sizes, which take their origin from the brain, or the spinal marrow, are diffused over every part of the body, and are the means by which sensations are conveyed, and the will exercised. The subject, however, requires more particular elucidation; and I propose it as the employment of the present occasion.

The brain is that particular organ which is placed in the head. It consists of two parts, one of which, the anterior and larger, is termed the cerebrum, or brain; and the other, which is the smaller, is seated at the lower part of the back of the head, and is denominated the cerebellum, or little brain; but, in common language, the whole contents of the head are termed the brain.

CHARLES.

Is the brain capable of being divided into different parts?

DR. A.

Most minutely; but I do not think this division will interest or instruct you; and I shall give you no more of it, than is merely necessary to afford a general view of the nervous system.

SOPHIA.

The brain must surely be exquisitely sensible, since it is the organ of sensation in the body?

DR. A.

In that you are mistaken. The substance of the brain is entirely devoid of sensibility, though it is the last apparent link in the chain of sensation; that, beyond which, further investigations have hitherto ended in nothing but idle and useless speculations. — The brain is made up of a kind of pulpy matter, grey in the outer part, which is termed the cortical or cineritious substance, from its external position and its ash colour; and white within, which is termed the medullary, from being of the white colour of marrow. Its external part is composed of what are termed convolutions, or doublings, like the puckers of dress; and the whole is protected by three membranes, or thin coverings, the two exterior of which stretch over the doublings; while the interior accompanies and covers every part of them, dipping down, and returning, for the purpose of passing on to the next convolution. These membranes are termed likewise the meninges of the

brain, and the outer is called the dura mater; the inner the pia mater; and the middle, from its being as thin and fine as a cobweb, the arachnoid coat. It must be observed, however, that the outer coat, the dura mater, which is very thick and strong, and which is firmly attached to the inside of the skull, and divisible into two laminæ, though it does not pass into the convolutions of the brain, yet forms certain expansions, called processes, which separate the hemispheres from each other, as well as the cerebrum from the cerebellum. It also forms, between its laminæ, certain cavities called sinuses, which answer the purpose of the larger veins in other places.

CHARLES.

I cannot conceive what relation the names, *dura* and *pia mater*, can have to the nature or uses of these coverings.

DR. A.

They are fanciful enough; but the appellation of mater, or mother, is given, from their being supposed to be the source of all the other membranes; and dura, hard or firm, is applied to the outermost, from its great comparative firmness and tenacity; while pia, pious, natural, or affectionate, is applied to the innermost, from its taking the brain into its folds, and embracing it, as a good mother does her child. You will thus see that anatomists

have just been as fanciful, in their epithets, as astronomers, in the names which the latter have given to the different constellations. — The cerebrum is divided, vertically, from before backwards, into two hemispheres, or half spheres, called the right and left hemispheres. It is united at its lower part, to the cerebellum, and from them both proceeds the spinal marrow, which is, as I have before mentioned, the substance contained in the cavity of the back bone, or spine.

From the little sketch which I now show you, you will form an idea of the mode in which the cerebrum and cerebellum are distributed in the

head, this being a vertical section. The cerebrum occupies the whole upper part (*a a a*) of the skull,

and the cerebellum is confined to the very lowest and back part of it (*b*). In the cerebellum you will observe, that the medullary and cortical matter are so distributed, as to assume an arborescent appearance which has been called the tree of life, arbor vitæ. In the cerebrum, on the other hand, the external cineritious matter has more the aspect of a dark, undulating border, round a white centre of medullary substance. The medulla oblongata, or oblong marrow, (*c*), lies at the bottom of the cerebrum, immediately before the cerebellum, and is the term given to the spinal marrow, till it leaves the skull.

In another little sketch, you must suppose the

brain taken out, and placed with its base uppermost. There will then present themselves the brain (*a a*), the cerebellum (*b b*), the medulla oblongata (*c*), terminating in the spinal marrow (*d*).

CHARLES.

Is the brain entirely solid, and continuous, or has it any cavities?

DR. A.

It has four cavities or ventricles, as they are called, which contain generally a small, but in hydrocephalus, or water in the head, frequently a large quantity of fluid. The two first are denominated the lateral ventricles, the others the third and fourth, and they all communicate with each other: but of these, and various points in the minute anatomy of the brain, it is impossible to form any idea from description, and very little from even the best drawings. From the lower part of the brain, nine pairs of nerves pass off through small holes in the skull, principally to the organs of sense, and the muscles of the face, eye, forehead, and tongue. From the whole length of the spinal marrow, thirty-one nerves are sent out, from each side, through appropriate holes. These last, either separately, or in various combinations with each other, or with branches transmitted from some of the nerves of the head, furnish all the other external and internal parts of the body with the

influence which is necessary to the exercise of their respective functions.

CHARLES.

Does it appear to you, that there are any particular parts of the brain which may be considered as more especially the source of our feeling? I have heard of some notions relative to the pineal gland being the seat of the soul. I think it was Descartes's idea.

DR. A.

It was so; but this was nothing more than a vagary of the imagination. The pineal gland is, in truth, a very small glandular body, like a pea, very deep seated, and attached to the contiguous parts by a small peduncle. It is remarkable for always, in adults, having a portion of sandy matter in it, which is the phosphate of lime. But this circumstance, with very few exceptions, is confined to the human race. Some other parts of the brain have, with equal reason, been elevated to the same dignity which Descartes conferred on the pineal gland.

CHARLES.

Philosophers seem to have racked their ingenuity to discover a certain centre, or seat of sensation. Instead of making this in the centre of the head, which seems to be the natural position for it, Gall and Spurzheim, I think, place it in the very outside, and direct us to look for the seat of mental faculties in mere elevations of the skull.

DR. A.

Their ideas are speculative enough, but you do not quite understand their bearing. The elevations of skull are only viewed as indications of proportional elevations of brain, in which the organs of particular faculties are supposed to reside. The skull itself, being originally soft, was, as it were, moulded upon the brain, and took its shape from it; and on the surface of the various parts of the latter, it is supposed, that the organs of the various faculties are placed, forming certain projections, cognizable by means of the bony elevations formed upon them.

CHARLES.

But I have heard of various injuries of the brain, by which portions were lost, and yet the patient completely recovered. Now I do not understand how this could be the case, when, according to this doctrine, the removal of no part could occur, without the corresponding loss of an organ, or part of an organ.

DR. A.

The founders of craniology, cranioscopy, or phrenology, (for it is known by all these names), have anticipated, if not removed this difficulty, by stating, as a basis of the doctrine, that the organs are all of them double, and that in all the instances which have occurred of loss or destruction of any particular part of the brain involving an organ,

the opposite organ remained untouched, and was, therefore, sufficient to carry on its particular function, just as one eye will answer the purpose of vision, when the other happens to be lost. It is also to be observed, that though Gall and Spurzheim make the seat of the organs external, they deduce their origin from deep-seated parts, as I shall endeavour to explain to you.

I have already mentioned, that there are two particular parts, of which the substance of the brain is composed, the cortical or cineritious, and the medullary. Gall and Spurzheim consider the latter as fibrous, and suppose that it was derived from, or produced by, the cineritious substance, which they regard as the first that existed in the original formation of the brain, and as that which, by means of its numerous vessels, formed the medullary or fibrous part, in which last they likewise comprehend the nerves. They endeavour to show, that the fibrous matter is invariably the product of the grey or cineritious; and think they can trace the whole of both cerebrum and cerebellum, to the medulla oblongata, from which they imagine that they had their ultimate origin. In the whole contents of the head, as well as in the spinal marrow which descends from it, they state, that the grey, or cineritious matter, is so disposed, as to keep up the fibrous; and hence they infer, that the different parts of the brain and of the

spinal marrow; that the nerves which proceed from the brain, and which chiefly supply the organs of sense; that those which issue from the spinal marrow, and are principally devoted to the muscles; and that those which are distributed within the chest, and the cavity of the abdomen, have no common source, but that every part has its separate origin, and that the various parts now mentioned, are only brought into a sort of general communication with each other.

This is therefore a sketch of their anatomy of the brain and nerves. Now they suppose that there is a peculiar organization bestowed on different parts of the surface of the brain, just as there is to the organs of sense, in order to communicate to us the faculties of memory, imagination, and judgment, as well as of every other power and propensity which may be possessed. But as they deduce the brain originally from the medulla oblongata, they suppose that this is the ultimate origin of the particular organ, which is developed, and made fit for its office on the external surface of the brain.

CHARLES.

Then, in fact, we may consider the organ as extending from the medulla oblongata, and comprehended between two radii, terminating at the surface of the brain.

DR. A.

So it would appear; but then as the organ has

both width and breadth at the circumference or surface, it may be likened in some degree to a cone, having its apex in the medulla oblongata, and its basis at the surface of the brain. The whole of the system of organs has been compared, by phrenologists, to an inverted cone; but each particular organ seems to be a cone likewise, according to the description given of them; and in consequence of the space which they thus occupy, attempts have been made to note them by an instrument to which the name of craniometer has been given. This is, however, a refinement which originated with the disciples of Gall and Spurzheim, and not with themselves.

HARRIET.

I have talked with friends who attended Dr. Spurzheim's lectures when he was in this country, and were quite in raptures with organizations, developments, and manifestations. I should be very curious to have the seat of the different faculties pointed out; for, to confess the truth, I find it rather difficult to follow the anatomical description which you have given us.

DR. A.

I am glad that I have it in my power to shew you, from Dr. Spurzheim's craniological work, a side, front, and back sketch of a head; on which you will see that the situation of the different facul-

ties and propensities is designated by particular numbers. The respective organs are arranged in three divisions; namely, those relative to the *propensities*, which are situated on the lower part of the head, and are numbered from 1 to 9: those relative to *sentiments*, which are placed on its upper part, and are numbered from 9 to 18: and those relative to *intellect*, which have their seat in the fore-part of the head, and are numbered from 18 to 33. The limits of the respective organs are denoted by lines; but, in order to show you, at one glance, the particular position of the organs of the propensities, of the sentiments, and of intellect, I have made a broader line to denote the boundary of each of the general divisions of those organs.

The seven organs which relate to the propensities, with their respective numbers, are as follow:

No. 1. Amativeness;

No. 2. Philoprogenitiveness, or love of offspring;

No. 3. Inhabitiveness, or the attachment to particular places;

No. 4. Adhesiveness, or attachment to particular individuals;

No. 5. Combativeness, courage, or the love of fighting;

No. 6. Destructiveness, or the propensity to destroy;

No. 7. Constructiveness, or the propensity to build;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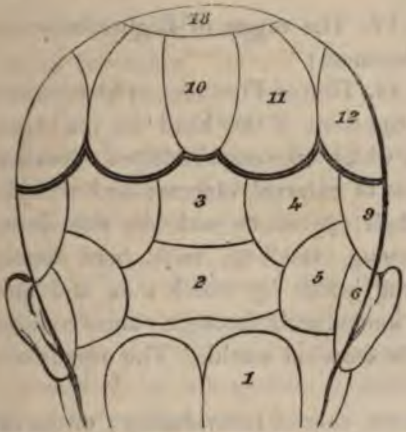

No. 8. Covetiveness, or Acquisitiveness, the disposition to covet, and to pilfer; and

No. 9. Secretiveness, that to conceal.

The nine next organs relate to sentiments, and are as follow:

No. 10. the organ of Self-love;

No. 11. that of the Love of Approbation;

No. 12. of Cautiousness;

No. 13. of Benevolence in man, or Meekness in animals;

No. 14. of Veneration;

No. 15. of Hope and Faith;

No. 16. of Ideality, or poetical talent; immediately above which is a blank space, which is supposed to be the seat of the organ of Wonder;

No. 17. The organ of Righteousness, or Conscientiousness;

No. 18. That of Firmness, or Determinativeness.

On the front of the head are the organs of intellect, which take cognizance of the existence and qualities of external objects; and therefore combine their operations with the five senses, hearing, seeing, smelling, taste, and touch, which form the means by which man and animals are more immediately brought into communication with the external world. The organs of intellect are,

No. 19. that of Individuality; or the desire and capacity to know facts and things;

No. 20. that of Form;

No. 21. of Size;

No. 22. of Weight;

No. 23. of Colour;

No. 24. of Space or Locality;

No. 25. of Order;

No. 26. of Time;

No. 27. of Number;

No. 28. of Tune;

No. 29. of Language;

No. 30. of Comparison; that of seeing resemblances, differences, and analogies;

No. 31. of Causality, or the love of metaphysics;

No. 32. of Wit; and lastly,
No. 33. of Imitation.

CHARLES.

What a curious assemblage is here brought together. Such a cluster of virtues and vices, sympathies and endowments, just as bewildering as are the stars on a globe, or in the heavens, to the uninformed in astronomy. But I am most astonished at the idea of the organs of crime; of a propensity to destroy, and a propensity to pilfer. According to this system, a culprit may put his hand to his head, and plead, in abatement of punishment, the protrusion of a well-developed cone, the manifestation of a full-grown bump. There would be no resisting his plea.

HARRIET.

Particularly when he could claim a sort of sympathy or fellow-feeling with the judge and jury; for if I understand the doctrines of craniology aright, the organs are common to all mankind; some persons only possessing a greater amplitude of particular organs than others.

SOPHIA.

But then you forget that what might be his justification, might, with a craniological judge or jury, be his conviction; for, among true believers, if evidence were at all dubious, there would be no

withstanding a well-marked elevation in a critical spot.

HARRIET.

But, Charles, I think the prisoners at the Old Bailey receive the reflection of a looking-glass upon them, in order to exhibit their countenances to the jury. This would be rather an unfair advantage given to an acute phrenological juryman; and as the English law is merciful in its application, such a power of inspection should not longer be permitted.

SOPHIA.

There is one mode, however, by which the measure which you propose, Harriet, would be rendered unnecessary.

HARRIET.

And what is that, Sophia?

SOPHIA.

By furnishing the prisoners with either wigs or night-caps.

DR. A.

Upon my word, good people, craniology is rather roughly handled by you. I must tell you, however, that you may save yourselves the trouble which you propose; for there is no discovering a projection which is covered with hair, unless by the touch; and, therefore, your fears for our criminal jurisprudence may vanish.

HARRIET.

But I think it must be admitted, that the detection, by whatever means it may be effected, of a well-manifested organ of covetiveness or destruction, would be a strong confirmatory proof of guilt.

CHARLES.

The Bow Street officers might, at any rate, get some important hints in their vocation, by attending to the seats of the propensities; and Sir Richard Birnie, Mr. Chambers, and even the Lord Mayor himself, might derive no little advantage in the detection of crime, if they would become zealous students of phrenology. I should not wonder, considering how numerously Dr. Spurzheim's lectures were attended in both ends of the town, and in all parts of the country, to hear, in no long time, of persons being taken up as suspicious characters, merely because they possess an unfortunate development.

SOPHIA.

Care must be taken, however, in such a case, particularly if the parties are Irish, that the development has not originated from the operation of a fist or a cudgel.

CHARLES.

As the organs are double, an examination of the other side would clear up the difficulty.

HARRIET.

But to speak seriously, I feel a great difficulty in considering virtues and vices as dependent on certain structure; and I should like to know how persons can be regarded as accountable for their actions, in whom nature has not only planted the seeds of virtue or vice, but actually brought them to great maturity. Is it supposed that any sort of moral control is capable of being exercised, which can affect the developement of certain organs?

DR. A.

Spurzheim says, that the inferior faculties should be subordinate to the superior, and that the victory which the superior faculties gain over the inferior, is virtue. If the combat is difficult, the merit of vanquishing is great; and if in all men, he adds, the superior faculties were eminently active, and the inferior less, and only proportionate, every one would do good from the love of doing so. One of his most able and zealous disciples, Mr. Combe, exemplifies the effects of education, by supposing two persons, in whom the organs are developed in an average degree, and one of them educated among people of sordid and mercenary dispositions, the other in moral and religious society. The first would have covetiveness and self-love highly cultivated, and therefore self-interest would be his leading object. The organ of love

of approbation might co-operate and produce the desire of distinction in wealth or power; and veneration, that of admiring the rich and great: while conscientiousness might be too weak to offer any control. On the other hand, with the second, the love of approbation would desire esteem for honourable and virtuous actions; and covetiveness would be viewed principally as the means of procuring gratification to these higher powers. Hence he considers, that the practical conduct of such persons might be very different, from this difference of training. One organ, it appears, must, therefore, be opposed to, or made to co-operate with another; but whether the effect of this is an additional elicitment of one organ which may be scantily, or the diminution of another which may be abundantly developed, does not quite appear.

CHARLES.

There is, I suppose, some connection traceable between the organs of sense and the brain; and I should be anxious to know whether, in phrenology, any apparent designation or division of organs exists, or any thing which can point out the termination of one organ, or the commencement of another.

DR. A.

All the organs of sense are constituted of an expansion of nerves, and in those which are

placed in the head, the nerves are traceable to the seat of the organ. Nothing of this kind can, however, be said of any of those organs which are described by phrenologists, and no particular divisions are apparent, except the mere elevation of the surface of the brain, which answers to the prominence externally. Such is the deduction, at least, which is made on an ordinary inspection of the convolutions of the brain; and this I believe was also the original idea entertained on the subject by Gall and Spurzheim.—Spurzheim, however, it must be observed, has stated in a late work, that he can at any time, by an inspection of any given portion of the convolutions of the brain, determine the particular part of the brain from which it has been taken, and, therefore, the particular organ to which it belongs. This is a minuteness of discrimination which is very extraordinary; and I should be exceedingly curious to see it put to the test.

CHARLES.

But are elevations of skull always necessarily indicative of corresponding elevations of brain?

DR. A.

Generally, but not invariably so; for at the eye-brows, for instance, the elevations are those of the walls of the frontal sinuses, which are cavities existing there, varying in magnitude in dif-

ferent individuals, and communicating with the nose. These elevations therefore do not evince the prominences of the brain within; for the inner surface of the projecting part does not come in contact with brain. The same happens, likewise, as to some of the projections near the basis of the skull, in the neighbourhood of the ear.

HARRIET.

Do the phrenologists think that there is any sort of analogy between the mode in which the dispositions of men and brutes are indicated? for I observe that the 13th organ is called that of benevolence in men, and of meekness in animals.

DR. A.

They certainly derive many of their facts and reasonings from considering the form of the brain in animals, as well as man; and, in particular, the whole of the organs which relate to the PROPENSITIES are considered to be in common to both.

The organ of *destructiveness*, they maintain, is possessed in a high degree by carnivorous animals; and by some of these more than others: for while certain animals only kill what they require for food, others destroy for the pleasure of the thing; just like a little naughty dog of Gall's, who used to watch several hours for a mouse, but would leave it as soon as it was destroyed. The organ is very large in lions, tigers, and

keen sportsmen; and was found to be greatly developed in the heads of Thurtell, Bellingham, Buonaparte, and King Robert Bruce; the skeleton of which last personage was discovered some years ago at Dumfermline, and the skull formed the subject of a long paper in the Phrenological Transactions.

The organ of *combativeness* is large in Charibs, and in the lower Irish; and was more remarkable in all classes, in former, than more recent times. King Robert Bruce had an ample organ of this kind. So have carnivorous animals, and game cocks; and last of all, that amiable specimen of the softer sex, the scold.

SOPHIA.

But surely you are not serious in the examples which you give us of the application of phrenology. Are such exemplifications actually to be found in authors?

DR. A.

Assuredly; and you ought to take the information very seriously, for it is so given. — The *love of offspring* is greater in women than men, and their peculiar organ is therefore larger. Of twenty-nine women who were infanticides, twenty-five had this organ very small. It exists in a considerable extent in cows, sheep, dogs, monkeys, and poultry.

Magpies and ravens carry away money and spoons, and gather stones, and similar things of which they cannot make use. Some dogs prefer bad bits, which they steal, to good dishes which are given to them: these animals, it is said, have the organ of *covetiveness* strongly marked. Spurzheim tells a story of a young Calmuck, who was brought from Russia to Vienna, by Count Stahremberg, and became melancholic and nostalgic, because his confessor, who instructed him in religion and morality, had forbidden him to steal. The confessor, in consequence, gave him permission to steal, on condition that he would give back what he had stolen. The Calmuck profited by this permission, and stole the watch of even his confessor, during the consecration of the mass, and leaping with joy, gave it back after the mass was over.

SOPHIA.

This boy must then, I suppose, have had a considerable organ of benevolence, and of conscientiousness?

DR. A.

Probably so; but as I am no craniologist, I cannot solve this point. — The organ of *secretiveness* is large in American Indians; in debtors, who wish to conceal their real situation from their creditors; in good actors, and in all cunning persons; in foxes; in cats, as evinced by their sly

mode of watching for mice, without moving a limb; and in all animals which, if pursued, hide themselves dexterously.

The organ of *constructiveness* exhibits itself in considerable developement in architects, sculptors, and all those who excel in mechanical arts. It was found large in the great Raphael; and, singular as it may appear, in the skull of a distinguished milliner at Vienna. It is ample in rabbits, which burrow; and in beavers, marmots, and field-mice.—But it is always to be observed, that phrenologists, in giving the same propensities to men, as brutes, make this distinction; that men have some peculiar organs, which modify the operation of those which they possess in common with the lower orders of the creation; and thus give them the power of exercising a degree of self-correction and control, of which the latter are incapable. Of these organs, the five last, which relate to SENTIMENTS, are given as examples, namely, the organ of *veneration* (No. 14.); of *hope* and *faith* (No. 15.); of *ideality* (No. 16.); of *righteousness* (No. 17.); and of *determinateness* (No. 18.).

The organ of *self-love* (No. 10.) is represented as being rather common with the English, and as making them appear, to the French, cold, haughty, and supercilious. It is stated to be remarkable in horses, turkeys, and peacocks. The French, on the other hand, are considered as

having more of the love of approbation (No. 11.); and as, therefore, appearing to the English, vain, ostentatious, and absurdly complimentary.— Dogs and horses are gifted with a large share of this organ; and the fair sex, in a greater proportion than men.

The organ of *cautiousness* (No. 12.) is also more amply developed in women than men; and many animals which are particularly circumspect, as the roe, stag, polecat, otter, and mole, have a large share of it. So have those which place sentinels to warn them of approaching danger, as the chamois, cranes, geese, starlings, and bustards.

Benevolence in man, and *meekness* in animals, are described as being indicated by a certain elevation in the upper part of the frontal bone. (No. 13.) Wild, ferocious, and untameable animals are flat, or have a hollow here; and this is likewise the case with such animals as horses, cows, and dogs, when they are ill-natured and vicious, of which there are occasional examples. The power of taming animals is supposed to be connected, partly with the possession of the organ of *benevolence* or *meekness*, and partly of the organ of *individuality* (No. 19.), which is one of those of intellect.

Of the organs of INTELLECT, the organ of *form*, or of that of distinguishing persons (No. 20.), was largely possessed by our late king, George III.

So it is likewise by many animals, and also by honey bees, who can distinguish individuals of their own hives from those of any other.

The organ of *space* (No. 24.) is said to be remarkable in astronomers, geographers, and travellers by sea and land; and it is to this that the faculty is attributed, which enables animals to find their way back to places from whence they may have been taken. Spurzheim mentions several curious examples of this kind: — A dog was transported in a carriage from Vienna to Petersburg, and after six months it returned to Vienna. — Another dog was transported from Vienna to London, but he found means to get back. He attached himself to a traveller in the packet-boat, and went with him to Mentz, where he left him, and returned to Vienna. — Another was carried from Lyons to Marseilles, embarked, and was conducted to Naples, but he came back to Lyons by land. — Another found again his former master in Suabia, after having left his new master in Hungary. — Pigeons likewise have found their way home, though conveyed 30 leagues in a sack; so has the falcon of Iceland, however carefully confined; for often the first time it is sent against a heron, it ascends vertically into the air, distinguishes its regions, and takes the direction of the north. It is to the same organ that the power of migrating, and

of returning with precision to the same place, is referred.

The organ of *tune* (No. 26.) is described as being possessed largely by musicians, and by singing birds, particularly the males; and all the other organs have exemplifications of their existence given in persons who are distinguished by the faculties with which they are supposed to be connected. — You will now be able to form an idea of what phrenology is, and of the kind of evidence by which the opinions connected with it are supported. Independently, however, of craniological considerations, respecting which you will easily see, that there must be much difference of opinion, Gall and Spurzheim (particularly the latter) are excellent anatomists, and have great merit in their dissections of the brain, which have excited considerable interest among those who are most conversant with the subject.

CHARLES.

Milton speaks of the full fair front of our male ancestor; and painters and sculptors, as well as poets, seem to have denoted, in every age, the possession of great talents, and high elevation of mind, by an elevation of forehead, though they, perhaps, thought nothing of the fulness of brain which is thereby indicated. Hence there appears to have been a sort of general agreement, as far as this particular point in phrenology goes.

DR. A.

Certainly; and many physiologists, it is likewise to be observed, have, before the time of Gall and Spurzheim, referred the existence of particular faculties to particular parts of the brain; for instance, perception and attention, memory, reflection, imagination, moving power, common sense, natural instinct, &c.; but all these attempts at phrenological geography were well described by the great Haller, as being equally weak, frail, and short lived. — Sir Everard Home has likewise conceded, in some degree, to the principle of such speculations, in referring some particular faculties to particular parts of the brain; as, for instance, memory to the cortical part of it, the communication of sensation and volition to a transparent mucus or jelly, which enters into the composition of both brain and nerves, &c.; but he is not, in my opinion, to be congratulated on the success of his speculations.

SOPHIA.

Do you apprehend that craniology leads to materialism? I have heard it much deprecated upon that score.

DR. A.

When we admit, as we must do, that there is a connection existing between mind and body; between the functions of the brain and vitality; be-

tween a certain organisation or structure, which enables the organs of sense to report the information derived from without, to a directing agent within; we leave the nature of this agent untouched by any speculation as to the number of senses or media, which nature, in her wisdom, has chosen to employ in obtaining information, or in exercising the functions of life or intellect. — The objections to craniology, as leading to materialism, does not, therefore, appear to be well founded.

CHARLES.

The illustrations which have been brought forward to exemplify the different doctrines of this science, have an aspect so very fanciful, and frequently seem to border so much on the ridiculous, that I cannot help considering this circumstance as likely to diminish the chance which the subject, whatever may be its intrinsic merits, has to obtain attention from the more judicious part of society.

DR. A.

This is not at all an improbable supposition; but we must defer the consideration of the remaining circumstances relative to the brain and nervous system till another opportunity.

CONVERSATION VIII.

THE BRAIN AND NERVOUS SYSTEM CONTINUED.

SOPHIA.

I WAS going to remark, at the close of our last conversation, my surprise, that considering the great importance of the brain, portions of it should have been lost, and yet patients recover.

DR. A.

Injuries to this organ are always necessarily of a serious description: they are principally so, however, when there is any pressure upon it; and therefore in cases of fracture of the skull, the principal danger arises from the pressure, either of bone or of effused blood, which it is the intention of the operation of trepan or trephine to remove.

CHARLES.

What is the nature of this operation?

DR. A.

It consists in the use of a circular saw, by means of which a piece of bone is removed, of the size of a shilling; and by the repetition of this

operation, if necessary, room is given to let out effused blood, and to separate or elevate depressed pieces of bone, which press on the parts below. The trephine is a sort of centre bit; but it is to be employed with much care and delicacy. Its derivation from a Greek word, to turn, is obvious. Sudden injuries operate strongly; but various alterations in structure, provided they are gradual, may take place, without either the suffering or the disadvantage which might be imagined, when so important an organ is affected. I may mention, by the way, a very curious effect which an injury on one side of the brain frequently produces; and that is, a loss of power, not of the muscles of the same, but of the opposite side of the body to that in which the injury takes place.

CHARLES.

That is very extraordinary: then it appears that there is some sort of an interchange, or crossing of the nerves, or material of the brain, so as to occasion this singular phenomenon.

DR. A.

This must, of course, be the case; but the precise place where this crossing is effected, or the mode of its occurrence, is not altogether known. Anatomists have supposed, that because there is a sort of apparent interlacement in the upper part of the spinal marrow, the interchange takes place

there; but this does not seem to be case; for some parts which are supplied by nerves sent out from the spinal marrow, previous to this interlacement, are subject to the same law.

HARRIET.

Does the magnitude of the brain bear any sort of proportion to the capacities or abilities of the animal?

DR. A.

In some degree it does: but physiologists have not been able to lay down, with accuracy, any law upon this subject. Singular as it may appear, man has a larger brain, in point of absolute magnitude, than any other animal, with the exception of the elephant.

HARRIET.

What, larger than the horse, or the cow, or any of the larger quadrupeds?

DR. A.

Unquestionably; for if you look at the skull of any of these animals, you will see that its compressed, narrow, and elongated form allows but a small space for containing brain. Thus the largest brain of a horse weighs not more than 1 lb. 7 oz., while the smallest brain of man weighs 2 lb. 5 oz., and that of a child, not a great deal less. —Aristotle and Pliny made this important observ-

ation relative to the great magnitude of the brain of man; but some have likewise attempted to show, that the proportion of the brain to the rest of the body is greater in man than other animals.

CHARLES.

This would, I think, seem to follow from the actual size being greater.

DR. A.

Not exactly so; for in a small animal, you would expect to have a brain of less weight than in man, and yet its proportion to the weight of the animal might be greater. In point of fact, though this holds with regard to the larger animals, it does not with regard to many of the smaller. The human brain is about $\frac{1}{35}$th part of the weight of the whole body, while that of a horse is about $\frac{1}{400}$th part; of an ox, $\frac{1}{750}$th; of a sheep, $\frac{1}{350}$th; of an elephant, $\frac{1}{500}$th. On the other hand, in many apes, the proportion is from $\frac{1}{100}$th to $\frac{1}{22}$nd; in the dolphin it is $\frac{1}{25}$th; and in some birds, as the canary bird, is even as large as a $\frac{1}{14}$th.— The hopes, therefore, of physiologists, as to the discovery of the particular law on this subject, was disappointed; but it has since been remarked, and with every appearance of truth, that the size of the brain in man, compared with that of the nerves which proceed from it, is greater than in any other animal yet known. We know too little,

however, of the particular functions of the brain and its various parts, to be acquainted with the precise application of this fact; and, indeed, all the knowledge which we possess on this subject, shows how ignorant we are, as to the inscrutable connection which exists between vitality and corporeal function.

CHARLES.

I suppose there is some resemblance between the nature of a nerve, and that of the brain.

DR. A.

Microscopic observations have made it probable, that both the brain and nerves consist of minute globules, held together by a soluble, transparent, coagulable jelly, or mucus, which Sir Everard Home, as I have already mentioned, considers to be the medium through which sensation and volition are communicated. The nerves are divided into minute fibrils, having a delicate covering from the pia mater, and the whole invested with condensed cellular membrane, as an external covering. —It has been supposed by many, that the brain is a secreting organ, and that a substance called nervous fluid is produced by it, which is conveyed along the nerves as tubes. Others have conceived, that the nerves act by communicating vibrations of different descriptions and degrees of force to the brain; and others, that nervous energy is a sort of electric

aura, or influence, of the most subtle description, to which the nerves act as conductors. These hypotheses may be ingenious and amusing, but they are visionary, and totally useless, except as far as they may lead to the discovery of new facts. I shall have occasion to notice to you the operation of galvanism on some of the functions of the animal body, particularly digestion, which have been considered as favouring the last idea.

CHARLES.

It appears from what you have mentioned concerning the properties of nerves, that they exercise, at the same time, several distinct functions; they communicate sensation from without, and convey the power of motion, and the will to carry it into operation, from within. Is there any thing known concerning this division of function? One would be tempted to imagine that there were different nerves, appropriated to purposes seemingly so different.

DR. A.

If that could be substantiated, it would be one of the most valuable additions to our knowledge of the nervous system which has ever been made. It has, indeed, frequently been imagined, both in ancient and modern times, that some nerves serve for sensation, and others for motion; and that both of them, though distinct in their origin, unite to-

gether in trunks, and accompany each other to the different parts of the body; but such ideas were little more than speculative. A distinguished physiologist of the present day, however, Mr. Charles Bell, whom I have already mentioned to you as the author of the interesting work on the Anatomy of Expression in Painting, has, by an ingenious and highly creditable train of anatomical investigation, rendered them exceedingly probable. It will not, perhaps, be carrying you too much into detail, to tell you, generally, what his ideas are on so obscure and interesting a subject. — He supposes that there are, besides the nerves of sense, four distinct systems of nerves combined into a whole, viz. nerves of sensation; of voluntary motion; those connected with respiration; and, lastly, those which are conducive to animal existence, or nutrition, growth, and decay. These nerves he states to be sometimes separate, sometimes bound together, but as never, in any case, interfering with, or partaking of each other's influence. You will see by this little sketch, the mode in which he considers filaments of nerves for different purposes as bound together; A being a nerve, consisting of distinct filaments; B, one of the threads dissected out from it.

CHARLES.

But then has he traced any of these nerves to their termination, so as to make out the functions which they exercise?

DR. A.

This he has done in many instances, and is satisfied as to the accuracy of his conclusions.— He considers the spinal marrow as consisting of two parts, one right, and the other left; and each of these parts as consisting of three columns, the anterior for motion, the posterior for sensation, and the middle for the actions of respiration. The various parts which are supplied from the spinal marrow are therefore furnished with compound nerves, or rather bundles of nerves, of different descriptions, which, at their extremities, are divided so as to furnish sensation or motion, as the case may be. If a nerve of sensation is divided, sensation, and not motion, will be lost; and if a nerve of motion, motion, but not sensation; and if that part of the spinal column should be injured, which gives rise to one or other of these systems

of nerves, the nerves which arise from them, whether of sensation or motion, will entirely lose their power.

CHARLES.

This is a very interesting view of the subject, and certainly removes the difficulty with regard to a certain independence of sensation and muscular power on each other. But, then, are we to view, according to Mr. Bell's idea, the spinal marrow as another brain, giving influence and power to the nerves arising from it, independently of its connection with the brain?

DR. A.

Mr. Bell traces the columns of spinal marrow which belong to sensation and motion, upwards to the brain itself; and hence he infers, that these columns deduce, from the latter, their ultimate energy. From these columns within the skull, he likewise traces the origin of such of the nerves which are sent out by the brain, as are destined for communicating sensation, or muscular power, to the face and head.

HARRIET.

You spoke of a third column of the spinal marrow, that which was appropriated to furnishing the nerves of respiration; but I cannot understand why there should be any occasion for a separate class of nerves for this function, since respiration

is a voluntary effort, which we have the power of stopping at pleasure.

DR. A.

We have, unquestionably, a certain voluntary power over the act of respiration. We can stop our breathing to a certain extent; we can breathe more or less rapidly, and have the faculty likewise, of employing it in accomplishing some other operations, as those of smelling and speaking; but then we know that during sleep, and insensibility from disease, respiration goes on independently of the will; and that even with the possession of full consciousness, we are unable to repress coughing, sneezing, crying, laughing, and vomiting, in all which phenomena, the muscles which are subservient to respiration, and which you will find when I treat of that function, are very numerous, are more or less concerned. Mr. Bell, therefore, considered it as necessary that these muscles should have a peculiar set of nerves, for associating them together in the various actions of respiration.

SOPHIA.

But there are, then, nerves supposed to be possessed, over and above the usual nerves of sensation and motion?

DR. A.

Certainly; the muscles in question have the ordinary demands of other voluntary muscles on

the nerves of sensation and motion, and the respiratory nerves he conceives are superadded. Mr. Bell observes, likewise, that animals which do not respire, are without this set of nerves, and that, as the functions of these nerves are independent of reason, and are capable of being exercised independently of the brain, or when separated from it, the column from which they are derived does not extend to the brain, but is lost in the medulla oblongata, the upper part of the spinal marrow. He has satisfied himself, that five nerves which come out from the central of the three columns which I have just mentioned, near the commencement of the medulla oblongata, are destined to that function, and infers that the remainder of this central column, through the whole extent of the spinal canal, supplies roots to the spinal nerves, so as to give them an association with the action of respiration.

CHARLES.

If we can conceive a muscle to be deprived of its sensitive nerve, and to retain its motive nerve, there would be a considerable difficulty as to our knowing how the muscle was affected, as volition from within could not be assisted by sensation from without.

DR. A.

This would certainly be the case, and so it has happened in the very few instances of this kind which have been mentioned by authors. In one,

a man who had lost the power of sensation in his hands and feet, but retained that of motion, was able to grasp pretty firmly; but in holding any thing was apt to drop it, if his attention were at all called away. In another, a female with a similar affection, was continually dropping various household articles on turning her eyes aside, which she could hold in safety as long as she looked at them.

Mr. Bell, too, found in a patient of his own, a female, in whom the nerves which imparted sensibility to the eyes and eyelids, had been pressed on by a tumour, which, however, did not affect the nerves of motion, that she could open and shut the eyelids, but she could not tell whether they were open or shut. From this and other considerations he deduces the very reasonable conclusion, that muscles require both species of nerves, which form a sort of circle between them and the brain; and that while one nerve conveys the influence from the brain to the muscle, another gives the sense of the condition of the muscle to the brain.

CHARLES.

You have mentioned, that there are nerves which supply muscles that are obedient to the will, and others which are appropriated to such as are partly voluntary, and partly involuntary muscles. But is there a particular set of nerves which are devoted to the muscles which you have named

to us as being entirely involuntary, such as the heart, the stomach, intestines, &c.?

DR. A.

Your question involves several points of great consequence in physiology. It has long been observed, that all the muscles, or muscular structures, which are independent of the will, are supplied from a particular nerve which is termed the great sympathetic nerve of the body, and has no immediate origin from either the head, or the spinal marrow, like the nerves of sensation and volition. This nerve is derived, in the first instance, from a small branch proceeding from one of the nerves of the head, and receives accessions from branches derived from all the nerves which it approaches, whether those of the head, neck, back, or loins. It is thus connected with all the other parts of the nervous system, as its name imports; but it is, to a certain degree, independent of them; forming a system of itself, and being destined to the supply of those functions which are too essential to life to be left under the influence of the will. — I may mention, likewise, that in various parts of the nervous system, the nerves are interwoven with each other, in a sort of network, called a plexus, the object of which seems to be, the prevention or diminution of eventual disadvantage, from any injury to a nervous trunk.

There are also, in various parts of the nervous system, small knots called ganglions, which seem to be made of a mixture of medullary and cineritious matter. Nervous fibres run into, and are lost in them; and others proceed from them; but it is observed that the latter are more numerous than the former; and hence it has been supposed, by some physiologists, that ganglions are to be viewed as a description of minor brain, and as therefore connected, in some way, with the production or increase of nervous energy. No satisfactory opinion has, however, been hitherto formed relative to their use in the animal economy. But both ganglions and plexus seem to have an important influence in producing the sympathy which exists between various parts of the body.

HARRIET.

What an extensive and beautiful system of operations is carried on throughout the animal body, by means of these small white threads; and how admirably nature seems to have provided, by their means, for an extensive sympathy of one part with another, over the whole machine. But have all orders of the animal creation brain and nerves, like man, and the higher descriptions of animals? or does nature provide other modes of producing the same effect?

DR. A.

I have already mentioned to you, that in man

the magnitude of the brain, compared with that of the nerves, is greater than in any other animal. The higher orders of animals, (those with vertebræ, which include the mammalia, birds, many fishes, and serpents,) have likewise brain, spinal marrow, and nerves, which vary in their proportions to each other, and in many points of organisation; but many of the lower orders, as worms and insects, have merely one or two longitudinal nerves in the centre of their bodies, having in them various knots, or ganglia, from which other nerves proceed; and having, some of them, at one end, a slight enlargement, which may be considered as a brain. This is the most simple form of nervous structure, and resembles, in some measure, that particular part of the nervous system, the sympathetic nerve, which exists in the higher orders of animals; but while in the latter, the sympathetic nerve is solely applied to the organs concerned in the natural functions, namely, those of growth and nourishment, the longitudinal nerves exercise, in the lower orders of the creation, all the functions of the nervous system which are necessary to sensation, muscular motion, and the support of the animal. These animals may, indeed, be considered as having nerves, or rather brain, universally diffused over them; and many of them, as they are liable to accidents, possess a power of repair and reproduction, which is exceedingly wonderful.

SOPHIA.

I was much struck with the reproduction of the claws of lobsters and crabs, which you mentioned to us: are there animals which go further than them in the possession of this power?

DR. A.

To a very great extent; and the lower we go in the scale of creation, the more surprising is the reproductive faculty. How liable is the earthworm to be injured by the unconscious gardener; but the injury, so far from diminishing animal life, increases it; for each portion into which the animal may be divided by the spade, becomes a separate creature, having a separate system of parts speedily regenerated. The head of the common snail, with its four horns, has been satisfactorily ascertained to be renewed in the course of six months; and in an animal of a more complicated structure, the water newt (the lacerta palustris), a complete eye was re-formed in the course of ten months, with all its various parts. The star-fish and anemone may have their tentacula removed, and they are speedily replaced; and if these animals are divided, two or more distinct animals are the consequence. But the fresh-water polype affords the most extraordinary example, of any known, of this wonderful power: for in whatever way it may be cut or divided, each part becomes,

in a few days, a separate animal, capable of all the functions of its parent. This animal is of a soft nature, like a common snail. It adheres by one end, like a sucker, to water plants, and other substances; and the other end, which is the head, is surrounded by many little arms or feeders, which seize and bring to the mouth, around which they are placed like radii, minute worms and water insects.

SOPHIA.

How very wonderful is this power; but we can hardly imagine that when such results take place from the accidental injuries of such creatures, they can have the same degree of sensibility as the higher orders of the animal kingdom.

DR. A.

We are, I think, entitled to infer that they have not; for nature, in providing for their preservation, and even extension, would hardly do this at the expence of so much suffering as would take place, if a worm, or a polype, underwent as much suffering from injury, as a man, or a quadruped. With the latter, insensibility and death are the result of severe injuries; and the beneficence of the Creator would not doom his creatures to those exquisite sufferings which must precede reproduction, if sensibility existed in the lower orders of

animals, to an extent similar to what it does in the higher.

Some of the animals which I have just mentioned, as star-fish, have no apparent nerves; but it may still be presumed, that they have something analogous to them, since the possession of sensation seems to be necessary to vitality; and sensations and various other functions of life are, invariably connected, in other parts of the creation, with a nervous system.

CONVERSATION IX.

OF THE ORGANS OF SENSE.

SMELL AND TASTE.

DR. A.

After having given you a general view of the brain and nervous system, I shall now pursue the subject into the organs of sense. By those I mean, the particular organs with which nature has endowed us, for the purpose of communicating impressions from without.

SOPHIA.

You mean, I suppose, hearing, seeing, feeling, smell and taste.

DR. A.

I do so; and it is by means of these organs generally, and by their particular modifications in different animals, that many of the various characters in the animal creation are produced.

CHARLES.

You mentioned that the nerves proceeding from the brain supply the organs of sense. You mean,

then, that certain nerves are distributed to these organs, so as to give them their particular fitness to receive and communicate impressions.

DR. A.

Certainly. The nerve of sight, or the optic nerve, is diffused over the retina of the eye, for the purpose of receiving the rays of light upon it, and transmitting the impressions which they produce, to the brain. The olfactory nerve is diffused over the membrane of the nose, in order to produce smell; the nerves of taste, over the tongue; those of hearing are spread into the interior parts of the ear; and the whole surface of the body has a delicate and extensive diffusion of nerves over it, which impart sensibility.

HARRIET.

Then, I suppose, there are differences in these nerves, by means of which they are capable of receiving one kind of impression, and not another.

DR. A.

That there are differences, we are very sure; but in what they consist, we know nothing; except, perhaps, that we can perceive some little dissimilarity of appearance in some of them, which in no way resolves the difficulty. Nature has imparted to the nervous expansion of different parts, different faculties; but why the retina, which is the

sensible part of the eye, should be capable of solely transmitting to us perceptions of sight, and not of smell; and why the faculties of the auditory nerve should be appropriated to hearing, is an ultimate fact for which we can give no account.

CHARLES.

May there not be a certain organisation of these parts, to which they may owe their respective faculties?

DR. A.

This may be the case for any thing that we know; but it would not remove the difficulty, if it were proved; for organisation is only another expression for minute structure, and if we could ascertain this ever so correctly, we still should be ignorant why the structure was connected with the possession of certain properties. The Creator has chosen to implant peculiar faculties on particular parts, and to connect with them certain varieties of structure and appearance; but there is no reason, except his will, that the skin should not see, or the ear smell.—It is necessary now, however, to enter into some details on the individual organs of sense, and I shall first consider the ORGAN OF SMELL, which I take first, merely because the nerves which are termed the first pair are devoted to this particular organ.

In the upper part of the face, there is a fine structure of thin, slight bones, covered with a fine membrane, called the Schneiderian or pituitory membrane, on which the olfactory nerve is diffused. These bones are of the thinnest and most fragile description, and are only intended as a sort of frame-work for the membrane to be spread over. They are protected from external injury by the firm and strong nose and cheek bones; but when any disease attacks them from within, they are very liable to serious molestation. The air conveying with it the subtle particles which constitute the materials on which smell is exercised, is applied, during inspiration, to the delicate and sensible olfactory organ; and thus the sensation produced, which has so constant a connection with the production of what is agreeable or unpleasant to us.

SOPHIA.

Are the nerves divided and subdivided on this membrane till they become invisible threads?

DR. A.

The olfactory nerve differs from most others, in being of a pulpy nature; and the expansion is therefore sooner lost than in many of the other organs of sense.

SOPHIA.

Some animals have great nicety of smell; is

there any peculiarity apparent in them, which gives rise to such additional perfection of sense?

DR. A.

The membrane on which the nerve is expanded, in such animals, is of larger surface, which arises from the peculiar bony structure which it covers, occupying a greater portion of the skull; and its divisions, or cellular structure, being therefore more extended. You may readily infer this, from the greater capacity of the nostrils, and the bones immediately contiguous to them, in hounds and pointers, which are remarkable for their smell, than in the greyhound, in which the nose is pointed, the face very flat, and the space appropriated to the expansion of the nervous matter very small. The hedgehog, the mole, the weasel, the bear, and the elephant, have a large space devoted to the convolutions of the pituitory membrane; and all these animals are remarkable for the acuteness of their smell. The seal is also very peculiarly gifted in its extent of smelling surface; and as this animal spends much of its time in the water, where the irritation of the water in swimming, particularly in a swift movement, might injure the sensible surface of the inner part of the nose, it has the power of closing up the opening into the nostrils, to prevent the inconvenience.

CHARLES.

One would think that the passage of the air through the nostrils, was likely to dry up the moisture, and therefore diminish the sensibility of the organ.

DR. A.

It would certainly do this, if it were not for a continual secretion, as well from the membrane itself, as from its expansion in various contiguous cavities. In the forehead, and in the jaw-bone, are cavities, called sinuses, which are lined with a continuation of this membrane. They thus afford, by their continual secretion, a fluid, which gradually distilling out of them, preserves the delicate membrane, on which the olfactory nerve is expanded, in continual fitness for its function. You may feel, in a common cold, a sense of fulness and weight on the forehead, which arises from a slight inflammation of the membrane lining two small cavities placed at the upper part, and near the centre of each orbit, and communicating by small openings with the cavity of the nose. These sinuses hardly exist at birth, when indeed the whole olfactory organ is but very imperfectly evolved. They may be considered as giving, in some degree, vibration and tone to the voice; and the openings into them are so placed, that the secretion which they produce may have an exit from one or other of them in every position of the body.

SOPHIA.

I have heard of persons having discharges from their brain through the nose. Such a thing must be of a very formidable description.

DR. A.

So it would be, if it were the fact; but these discharges are either from the increased or altered secretions of the sinuses, or the cavity of the nose; or from some affection of the delicate bones connected with the olfactory organ. The existence of such discharges from the centre of the head, was credited, even by medical men, till they became better acquainted with the anatomy and pathology of the parts.

CHARLES.

As the air which we inspire does not pass through these sinuses (for they seem from your description to be all of them culs de sacs), they are, I suppose, little connected with the exercise of smell?

DR. A.

They have acute sensibility, but it does not appear that the olfactory nerve is diffused over them, so as to constitute them a part of the organ of smell, probably for the reason which you mention.— The odorous particles of bodies must be of a very minute nature, when I tell you, that musk and

ambergris may diffuse a continual, and strong odour, for a long period of time, without suffering any diminution of weight. Haller found, that one grain of ambergris imbued 8000 square feet of paper with its peculiar odour, which was not lost during a period of 40 years: and you may readily conceive how minutely some substances are capable of diffusion, and how exceedingly small a portion is cognisable to the senses, when I tell you, that the same great physiologist calculated, that less than the two thousand millionth part of a grain of camphor is distinctly perceptible when diffused in air. Lord Valencia mentions, that the perfumes of Ceylon are to be discovered at nine leagues from it.

CHARLES.

The effluvium left on the ground by an animal passing over it, must be of an extremely subtle nature; yet it is palpable to dogs, and other hunting animals. I have often been astonished at the acuteness of their organs, so much beyond that of which we have any idea from ourselves.

DR. A.

This is a matter of profound admiration; and with dogs, it will even go to the extent of tracing out their master by scent, among many other persons. Birds seem also to have a very acute smell; and it is said by Shaw, that the burouras, or large

horned owls of the desert, during the existence of the plague at Algiers, used to hover over the town, and even pitch on infected houses; but they returned to their native deserts after the distemper ceased. Marvellous accounts have been given of Asiatic birds having been attracted to the plains of Pharsalia, after the celebrated battle which decided the fate of Rome.

HARRIET.

We hear of various savage tribes, among Indians, being endowed with a fine sense of smell. It would appear, therefore, that it is capable of being improved according to circumstances.

DR. A.

Many such accounts are given by authors; and I have no doubt that greater attention to the objects of perception will tend to cultivate its power; but it is even said that the olfactory organs are developed, in an extraordinary manner, in the individuals of some of those tribes, as if the necessity for the exercise of such faculty increased the actual quantity of the organ. Blumenbach, in his plates of skulls, gives the head of an American Indian chief, who was executed at Philadelphia, about the year 1760, for murder, in which the cavity of the nose was of extraordinary magnitude. He also mentions the skulls of some negroes as having larger nasal organs than are usual in human heads.

We have seen that domestication produced various changes in the characters and forms of animals; and that considerable alterations may likewise be effected by civilisation among the human race. It is to be remarked, however, that among Blumenbach's heads of negroes, there is a very great diversity in form, in elevation of forehead, in the facial angle, and in the magnitude of the nasal organs.

SOPHIA.

The sense of smell is, I suppose, universally given to animals; but there are some which do not breathe, as fish; where does the organ lie in them?

DR. A.

Most animals have the organ of smell; and those which are dependent on it in a principal degree for discovering their food, possess it in greatest perfection. Thus hunting animals, as we have seen, are of this class; and so are the graminivorous, which are, by their smell, led to the particular plants which are most suitable and acceptable to them. Fish have the nerves of smell diffused over their snouts, in order to give assistance to the organ of taste; but it may be observed, that the whale has no olfactory nerve, and seems to be entirely destitute of any organ of smell. The precise position of the organs of smell in insects

and worms is not known, though it has been ascertained that these animals are endowed with this sense. The spiracles, or breathing pores, which are openings that serve the purpose of the mouth, to admit air into the body of the animal, have been, in the former, regarded as the probable seats of the organ of smell: but Kirby and Spence, the authors of the delightful work on Entomology, which is so deservedly a favourite with the public, are of opinion that this sense is placed near the mouth.

The ORGAN OF TASTE has much connection with that of smell. By smell we are directed to what is grateful and salubrious; and by taste we derive a gratification in taking food, which insures our attention to the nourishment of our bodies, and therefore to the preservation of our health and existence.

CHARLES.

Is there any particular nerve which is appropriated to taste, as to smell?

DR. A.

Anatomists have not been quite agreed as to the particular nerve in which the faculty of taste resides; for the tongue, which, in man and some other animals, is the prime organ of taste, has likewise other duties to perform, for which it has a curious structure of muscles, which, in their

turn, require nerves. It appears, however, that the nerve of taste is a branch of the fifth pair, which is the nerve that gives sensibility to the face.

The tongue is composed of an assemblage of muscles, which are necessary for performing all the minute motions required in speech. It is covered, as the other parts of the body are, with skin and cuticle; but from the skin arise small elevations, or papillæ, most numerous on the point and edges, which are very vascular, and on which the extremities of the gustatory nerve terminate. Anatomists distinguish these papillæ by particular names, from their supposed shape or appearance, as pyramidal, fungiform, and conoid.

CHARLES.

The continual moisture of the mouth is doubtless intended to keep the organ of taste in proper order for its exercise?

DR. A.

Certainly; for you may observe that when the mouth is dry and parched, the power of tasting is lost, as happens on sleeping long with the mouth open.—For the purpose of taste, it is necessary that the food should be to a certain degree dissolved, or softened; for it could not otherwise enter into the inequalities of the tongue's surface, so as to give rise to the perception of taste.

SOPHIA.

Does the tongue then produce the spittle, or fluid, which keeps the mouth moist?

DR. A.

There is so much required for the purpose of lubrication, and also for moistening the food, during mastication, that besides the continual secretion of a fluid, which takes place from the mouth, in common with all other cavities, there are peculiar organs, or glands, situated in or near the mouth, which are destined for the secretion of the saliva, and which throw it into different parts of the mouth, by means of small ducts or tubes. Two of these glands, the parotid, are situated at the side of the face, and ascend upwards about an inch and a half from the angle of the jaw. An inflammatory swelling of these glands constitutes the mumps. Two others are situated under the lower jaw, called the submaxillary, and two under the tongue, called the sublingual.

SOPHIA.

Are these ducts which you mention capable of being discovered in the mouth?

DR. A.

A nice and experienced eye may detect them; but the flow of the saliva which they throw in is so gradual, as not to be capable of being discovered. A wound in the duct of the parotid gland,

when it runs along the face, is difficultly healed, on account of the continual stillicidium of saliva which takes place through it. Animals living in water are without this apparatus, which is obviously unnecessary in them.

CHARLES.

The power of habit seems to reconcile the taste to the most varied descriptions of aliment; whether it be the train-oil and the raw whale of the Esquimaux; the horse-flesh of the Tartars; or the greatest culinary refinements of civilised society.

DR. A.

This is wisely ordered by nature, in order to fit man for all the positions which he may have on the globe, and for the changes of abode which may occasionally be necessary for him. In animals, too, there is a certain latitude afforded to taste, according to the circumstances in which they may be placed; and we shall afterwards find, when we come to the subject of digestion, that ruminant animals, as cows, will occasionally reconcile themselves to a diet very different from their ordinary one.

CHARLES.

Is the tongue the only organ on which the nerves of taste are diffused? for it would appear, that in tasting, we employ both the tongue and the roof of the mouth, though this may, indeed, be merely for the purpose of applying the thing tasted to the papillæ of the tongue.

DR. A.

I believe it is principally with this view; though it has been thought that the nervous expansion extends in some degree to the palate, sides of the mouth, and lips. But it may be found, that if a portion of sugar, salt, or any other sapid substance, is rubbed on the tongue with the finger, the taste of the particular substance is distinctly perceived; on the other hand, this is not the case if the same substance is applied in a similar way to the palate, or any other part of the inside of the mouth. Blumenbach, however, mentions the case of a man who was born without a tongue, but in whom the distinctions of salt, sugar, and aloes, were readily perceived, and were expressed in writing, when any of these substances were rubbed on the palate. Here, however, it is not improbable, that some branches of the gustatory nerve might be communicated to the palate, in the absence of the organ on which they were usually bestowed.— The tongue appears to be an organ of taste in most animals; and in some of the graminivorous, it has elevations, directed inwards, which assist them in tearing up grass. Other animals, of the cat kind, have the tongue armed with sharp, strong prickles, which aid them in holding their prey. With some animals this organ is principally, if not entirely, intended as a means of procuring their food. The ant-eater, for example, thrusts its long hard tongue

out, and waits till a sufficient number of ants settle upon it, when it draws it in, and swallows them whole. The chamelion's tongue is likewise very long, and is covered with a viscous secretion, by means of which, when darted forward, the small insects which constitute its food are entangled.

In many birds the tongue, hard, pointed, or barbed, is thrust out as an offensive weapon, by means of a curious structure of appropriate muscles.

SOPHIA.

But it is difficult, in many of the examples which you have given, to state where the organ of taste can be, as the tongue is obviously incapable of acting in this capacity, from its hardness and insensibility.

DR. A.

It is probable, however, that the organ of taste may be situated behind, so as to receive its due gratification in the act of swallowing, which we know is the instant at which the enjoyment of the gourmand is complete.

END OF THE FIRST VOLUME.

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BY A PHYSICIAN.

IN TWO VOLUMES.

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CONVERSATIONS

ON

THE ANIMAL ECONOMY.

CONVERSATION X.

OF THE ORGANS OF SENSE.

VISION.

DR. A.

THE next subject to which I mean to direct your attention, is vision. This is, in many respects, the best understood of any of the organs of sense; and as the operations to which it is conducive, are of a most important and interesting description, and very much within our cognisance, it has at all times received very great attention from men of science. The eye may be considered as an instrument, allowing the entrance into it of rays of light, which, after various refractions, are impinged on its back part, in such a way as to communicate the impression of vision. It consists of a globe or ball, which is lodged in a

socket of bone, and has the optic nerve entering it at its posterior part, through a hole appropriated for the purpose. It has implanted into it various muscles, destined to give it motion, which arise from the bony case which surrounds it. — The bony case, or socket of the eye, is constituted of very thin bones; but the projecting orbit and cheek-bones are thick, are of considerable strength, and are therefore well adapted as a defence to the eye.

CHARLES.

I have heard of serious injuries, and even death being produced, by a push with a foil in the eye in fencing; and I suppose it is from the danger thus occasioned, that fencers frequently wear masks, for the more effectually guarding against such accidents.

DR. A.

Certainly; the eye might not only be seriously injured by a blow or a push, but the bone is little able to resist the application of violence; and hence in a violent lunge, the foil might even penetrate into the brain, and thus occasion death. — The eye consists of a white and coloured part; the former being called the albuginea, or white of the eye; and the latter, the transparent cornea. Within the transparent cornea, is a party-coloured circle, which is called the iris; and in the

centre of this circle is an opening, called the pupil, through which rays pass into the interior of the eye.

HARRIET.

Is the pupil then an opening? I always thought it was a solid black body.

DR. A.

It appears black, just as an opening into a dark cavern, or a dark room, seems so; but if, within the pupil, there should be any change of structure, by which there is an interruption to the passage of rays, and a consequent reflection of light, we then see that it is an opening in the iris.

HARRIET.

But it seems to be extraordinary that the blackness should be so intense; for one would imagine that there would be some glimmering from without, through the coats of the eye; and at any rate, that the rays which pass through the opening, would have some effect in diminishing the extreme darkness of the colour, just as they would the darkness of a room into which they might be admitted.

DR. A.

This would unquestionably be the case, unless for a wise provision, which a very slight consideration of the nature of light and colours will enable

you to understand. You will recollect that light, by means of a prism, is capable of being divided into seven colours, namely, red, orange, yellow, green, blue, indigo, and violet. The colour of a body consists in the reflection produced by it, of one or other of those rays, and the absorption of all the rest; while white and black may be regarded as the absence of colour; for in the one, the white, all the rays are reflected, in the other, the black, they are all absorbed. The interior of the eye is lined with a black pigment, which absorbs all the light that might otherwise pass through, or be reflected, and thus interfere with the exercise of vision, and hence arises the intense blackness which belongs to the pupil.

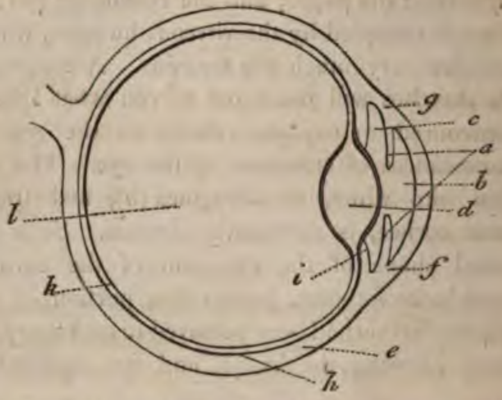
The eye is pretty nearly a ball or globe, composed externally of coats or layers, and internally of substances, more or less fluid, called humours. The whole external surface of this globe, with the exception of the transparent part in front, consists of a white, firm, hard investment, called the sclerotic, having within it the choroid coat, and last of all the retina, or visual part of the eye, which is an expansion of the optic nerve.

There are thus three coats, which form the principal investments of the eye; and there are also three humours, which fill its interior. The first, or the external, is the aqueous humour, consisting principally of water; the second is the

crystalline lens, or crystalline humour, which is a small, transparent, half-solid mass, lying immediately behind the pupil; and the remaining part of the eye is occupied by the vitreous humour, which resembles very much the aqueous. A couple of little sketches will point out to you what I have endeavoured to explain, relative to the general circumstances of structure of the eye. The division into white, or albuginea (*a*), and transparent cornea, is sufficiently obvious. So is the general shape of the eye, and of the cornea, placed in its forepart, just as if a portion of the opaque sclerotic had been removed to make way for it, and allowing the iris (*b*) and the pupil (*c*) to

be seen through it. Now to understand the interior of the eye, you must suppose a horizontal section of it, and that this is viewed from above. In this section, the iris (*a*) is supposed to be cut across, and to hang in the cavity which is devoted

to the reception of the aqueous humour, dividing this cavity into two parts or chambers; that in



the front (*b*), being called the anterior chamber; that behind (*c*), the posterior.— The aqueous humour is capable of speedy reproduction, when by any accident it may be removed.

Behind, is the crystalline humour or lens (*d*), which is a small transparent body, like a compressed sphere, covered with an exceedingly fine transparent membrane, or capsule, thick and glutinous in the exterior, and gradually becoming firmer and denser to its centre. It is of a fibrous nature, and has been, by some philosophers, supposed to have a muscular structure.

SOPHIA.

This is, I suppose, what comes out of the eye

of a fish after boiling; but in this case, heat must have the power of coagulation, so as to make the substance opaque, which was originally transparent.

DR. A.

Certainly; and the same effect would follow from immersion in alcohol. In both cases it will be found, that there is a pearly part within, which is of a much firmer consistence than that towards the circumference.

SOPHIA.

Is not this the part which is affected in cataract? for I recollect hearing a good deal about the crystalline lens, and an operation upon it, which our neighbour Mrs. S. underwent, some time since, and which restored her sight.

DR. A.

In a cataract there is a change in the character, either of the crystalline lens, the capsule, or both, by means of which they become opaque, and impede the transmission of the rays of light to the retina. The operation consists in either depressing the lens, that is, forcing it into the mass of vitreous humour below; entirely removing it; or carefully breaking down, with a proper instrument, the lens or its capsule, or both, and bringing the portions into the anterior chamber of the eye, where, by being subject to the action of the aqueous

humour, a sort of dissolution of the opaque portions takes place. Subsequent absorption, when the operation is of the latter kind, and succeeds, clears the eye of the obstacles to the entrance of the rays of light.

SOPHIA.

How dreadful must such operations be; and yet I was surprised to hear how well our neighbour bore hers.

CHARLES.

I should imagine, however, that considering the great body of the eye to consist of a fluid, or pulpy mass, there would not be much sensibility internally.

DR. A.

You are quite right. The exquisite sensibility of the eye is to guard it, externally, from the slightest approach of injury; for not only might a wound destroy its organisation entirely, but inflammation, by forming a speck on it, would prevent the passage of the rays to the interior of the eye, and equally interrupt vision. — The crystalline lens is placed in the anterior part of the vitreous humour (*l*), which is a fluid lodged in small transparent cells of extreme fineness, and occupying about three fourths of the globe of the eye. It is surrounded by a very delicate membrane, called the hyaloid membrane, and is not capable of reproduction, like the aqueous

humour, if lost. Being in cells, it appears to have a spissitude which it does not possess. The sclerotic coat (*e*) which forms the external investment of the eye, is so named from its hardness (σκληρωτις, hard). It is thick, tough, and firm, and forms the principal support and protection to the eye. The muscles which move the eye are inserted into it; and it is but little susceptible of inflammation. The front of the sclerotic coat, which terminates at *f*, *g*, has an opening in it, in which is fixed the cornea, extending from *f* to *g*, and so called from its horny texture. It is composed of lamellæ, in which a watery fluid is lodged, which is retained in its position during life and health, giving a plumpness to the anterior surface. At or before the close of life, this fluid oozes out, and forms the obscure film which destroys the transparency of the eye, and forms that most remarkable difference between the activity and brilliancy of this organ during life, and its dull obscured state in death.

HARRIET.

You speak of the sclerotic coat as being little susceptible of inflammation, and yet the white of the eye is frequently blood-shot, and exquisitely sensible to light.

DR. A.

This is from an affection of a subsidiary cover-

ing to the eye, called the adnata, or conjunctiva, which is a reflection of the common skin of the eyelids. It covers the inner surface, and then doubles back to invest the sclerotic coat and the cornea. It is very vascular, and is the seat of inflammation of the eye, or ophthalmia, as this is called.

HARRIET.

But how does it happen that a white surface, in which no redness is at all apparent, should be so far altered, as to become almost like a piece of scarlet cloth; for so I have seen the eye when inflamed?

DR. A.

In ordinary circumstances, the membrane, of which we now speak, is supplied with vessels so minute, as not to admit into them the red particles of the blood, which are, as I shall afterwards have occasion more particularly to notice to you, very small molecules, in which the colouring matter of the blood exists. When by the effects of disease the vessels enlarge, they admit particles into them, which were refused entrance when they were in health; and thus the redness is produced.—Within the sclerotic coat, is the choroid (*h*), which is loosely attached by cellular substance to the sclerotic; is very vascular; is divisible into two membranes; and has a villous or fleecy appear-

ance on the inner surface of the inner one. It secretes a covering of black paint, which, as I have already mentioned, lines the inside of the eye, and indeed may be said to imbue the whole substance of the choroid, in order to absorb any reflected rays which might render vision obscure: various optical instruments are likewise covered with black paint, in their interior, for the same purpose.

SOPHIA.

This covering of paint is of course wanting in albinoes, and in all animals which have red pupils. Since you mentioned the subject at our first meeting, we have had an opportunity of seeing a ferret, and were much surprised and interested with the difference between its eyes, and the ordinary eyes of animals. The whole of the eye which was not white, was of a fiery red; even the iris, which in its usual state is beautifully particoloured; but some of the rabbits had not red eyes, which agrees with what you mentioned to us as occasionally happening, when the other characters of the albino are present.

DR. A.

The choroid coat extends over the vitreous humour as far as the cornea, where it forms the ciliary circle (*i*), and processes. The iris is attached to it anteriorly, and is so denominated from

its various colours. Its posterior surface is called uvea, from having a mucous covering of a dark colour, resembling that of a raisin, which has been regarded as a prolongation of the choroid coat, and secretes a similar black pigment. The office of the iris is to act as a curtain, in order, by its contraction or dilatation, to allow more or fewer rays to pass into the eye, according to circumstances. It is suspended, as I have already mentioned, in the aqueous humour, which it divides into two chambers, and has been supposed to owe its power of contraction to a muscular structure. It does not appear, however, that the circumstances on which this depends are well understood; for contraction is not produced in the iris by the same stimuli which act ordinarily on muscular fibres; as, for instance, electricity or galvanism, or the touch of instruments during operations on the eye. There is, however, this circumstance favourable to the idea of muscular structure, independently of contractility, that it has been ascertained that the iris has all the chemical characters of a muscle, its constituent parts being fibrine, that particular substance of which muscles consist.—The inner membrane or retina (*k*), so called from its net-work structure, is nearly transparent, is exceedingly soft, and easily torn, and is composed principally of a medullary substance continued from the optic nerve. It is in contact with the

choroid coat, without being attached to it, and receives no tinge from its pigment. It is expanded over the vitreous humour (*l*), and is the immediate organ of vision; but it has been found to be without sensibility, when touched by an instrument during an operation. By the microscopic observátions which I have already mentioned, the optic nerve has been found to consist of many bundles of very delicate fibres, formed of minute globules, connected by a gelatinous substance; and the retina appeared to be a continuation of such bundles spreading like rays from the nerve to the circumference, where they almost disappear, and end in a smooth membrane. Though the retina is described as being in contact with the choroid coat, and as forming the third coat of the eye, yet, in point of fact, there is interposed between them, a very fine membrane, lately discovered by Dr. Jacob of Dublin, to which no name has yet been given. It is very delicate, almost transparent, and covers the retina from the optic nerve to the ciliary processes, and is common to man with most other animals: this therefore is, properly speaking, the third coat, while the retina is the fourth.

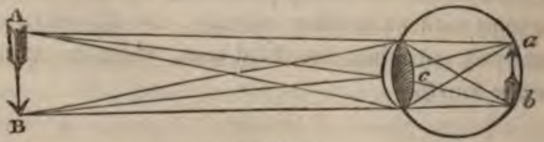
CHARLES.

We may view, then, the eye as a fine optical instrument, in which, for the purpose of conveying

the rays to the proper focus, a complete transparency is as much necessary, as the perfect cleanness and purity of the lenses, in the most perfect telescope or microscope.

DR. A.

The eye is the most perfect of optical instruments. The transparency of the cornea allows the rays to pass from an external object through it, into the pupil. If there is an obscure light, the pupil expands, and admits more rays; if there is a strong light, the pupil contracts, and cuts off an inconvenient portion of them. These rays, proceeding through the crystalline lens and the vitreous humour, undergo the various refractions necessary for giving them such a direction as will make them fall in foci on the retina, from which the impression is conveyed to the sensorium. This may readily be exemplified by a small diagram, in which rays from an object (A, B,) pass through the pupil, and the crystalline lens (*c*), and are impinged on the retina at *a*, *b*.



HARRIET.

I see distinctly how the refraction takes place, so as to effect the union of the rays at the bottom

of the eye. But the image of the object is inverted in the retina. Surely we do not see things upside down?

DR. A.

It is very true that the picture of an object upon the retina is inverted; but it is rather too mechanical an idea to suppose that the impression on the mind ought to be so likewise. In becoming acquainted with external objects, sight and touch go hand in hand in giving us the necessary information. Upper and lower are positions relative to the surface of the earth, and the situations of our own bodies relative to it. After, therefore, we have become acquainted, by touch, with the different parts of bodies, and have learned their position relative to ourselves, we know that by raising our eyes we bring them to a direction which we have been previously informed by touch, refers to the upper part of an object, without any reference whatever to the particular mode in which the impression is communicated. In this way the different situations of the eye, whether elevated or depressed, naturally direct the mind to make a suitable judgment of the situation of objects presented to it.

HARRIET.

Is the union of rays at the bottom of the eye a supposition merely, or has it been the subject of actual observation?

DR. A.

If the eye of a sheep, or any other animal, have the sclerotic coat and the choroid dissected from the retina, and be placed in a hole in a window-shutter, or a box, in such a direction as to admit only the rays from the sun or a candle through the pupil, the image of the object may be actually seen impinged on the retina. It is a matter of some difficulty to have this experiment performed in the best way; but here is the eye of a sheep, from which I have removed the sclerotic and choroid coats, so that you may see the medullary substance of the retina on the soft jelly of the vitreous humour. On shutting the shutters, and bringing near the front of the eye a small lighted taper, you will see the image impinged on the exposed surface of retina behind.

HARRIET.

I see it beautifully represented; and inverted too, just as in the diagram, which we have just seen.

SOPHIA.

This is a very satisfactory experiment, and one which does no harm; for I was afraid that it was by some uncomfortable process that the impingement of the rays on the back part of the eye was rendered evident.

CHARLES.

The usual laws of refraction are I presume

followed, in the passage of pencils of rays through the eyes, just as through any lens.

DR. A.

Certainly; and perhaps you can manage so as to make a little diagram of the mode in which it may be inferred, that the rays will pass on to the retina. You recollect the laws of refraction?

CHARLES.

When rays pass from a rarer into a denser medium, as from air into water, they are refracted to the perpendicular; when from water into air, from the perpendicular.

DR. A.

What would be the effect of rays passing from any object into the transparent cornea?

CHARLES.

If we make a small portion of a circle *a b*, to represent the cornea, and draw a pencil of rays from any object *c*, to the portion of circle at *d*, and passing through it, this pencil of rays, as it goes from a rarer into a denser medium, will be bent to the perpendicular, and the direction will be in *d k* instead of *d f*.

DR. A.

But then rays pass from all parts of an object, to all parts of the cornea; and in what direction would a ray impinged on *e* be directed?

CHARLES.

It would proceed in the direction *e k*, and in time would meet the other ray *c d*, in a focus at *k*.

DR. A.

That, of course, is on the supposition that the medium continues the same; but suppose that it were necessary to have a further refraction, so as to unite these rays nearer the object *c*, how could this be effected?

CHARLES.

By placing another substance as at *n*, of greater refracting power than the first, in the course of the refracted ray, in order to give it a further bend.

DR. A.

You would then, if the medium were the same, carry the ray on to *l*; but if you were required to unite the rays still nearer the object *c*, the medium not being increased in density, to answer to the increased density of the additional refracting body, you might find a shape in the additional refractor, which would answer the purpose.

CHARLES.

That would be the double concave lens, which, after bending the rays on entering the lens from a


c
e
d
b
a
m
n
g
f
o
l
k

rarer medium, to the perpendicular, in the direction *n l*, will, on their emerging at the opposite side of the lens, bend them from the perpendicular, and thus alter the direction to *o*, and produce a further convergence.

DR. A.

This is precisely the case with the eye, on which it is necessary that such a refraction should take place, as would produce the union, exactly at the retina, of the pencils of rays which enter it; and there is therefore a necessity for a further degree of refraction being produced, than the cornea and aqueous humour, whose density are pretty much the same, are capable of effecting. This takes place through the medium of the crystalline lens, which is a double convex lens; and it occurs very gradually; for as the refracting power is gradually increased to its centre, (where, as I observed to you, it is firmer and denser than at the circumference,) the curvature which the pencil of rays undergoes is very gradual.

CHARLES.

But then, according to the principles of optics, the focus will not be at the same point, when objects from which rays proceed are at different distances. Has the eye any power of adjusting itself to the different distances of objects, for the purpose of obtaining distinct vision?

DR. A.

It possesses such a power; but philosophers are not altogether agreed upon the mode in which it is exercised. I find, however, that I must defer the explanation of this matter, and the further prosecution of the subject of vision, till our next meeting.

CONVERSATION XI.

OF THE ORGANS OF SENSE.

VISION CONTINUED.

DR. A.

You asked me, Charles, when we last met, whether the eye possessed any power of accommodating itself to the different distances of objects, in order to obtain distinct vision; because you very properly observed, that the focus at which rays will unite, at the back part of the eye, will not be at the same point, when the objects from which rays proceed are at different distances. If the curve of the cornea were capable of alteration; or the retina, by some pressure upon the body of the eye which could lengthen its axis, could be made to recede; or if the crystalline lens could be altered in shape, so as to have its curvature changed; or its position in relation to the retina could be made to vary, then a slight degree of consideration will show you, that such an accommodation could be effected as would answer the purpose.

CHARLES.

The alteration of the curve of the cornea seems to be a very natural mode of producing the effect.

DR. A.

And a very effectual one too, if it were found to take place; but though this was rendered probable from some nice experiments made by Sir Everard Home and Mr. Ramsden, on the changes which occur in the convexity of the cornea in viewing objects at different distances, yet, as it was found by Dr. Young, that the eye possesses the power of accommodation when the cornea is in contact with water, and when therefore all the effect of its change of figure would be lost, it is clear that this opinion must be given up.

HARRIET.

I do not quite understand the necessity for the adjustment to different distances which you speak of; perhaps you can make the subject a little more intelligible.

DR. A.

If, in the diagram which I showed you (Vol. II. p. 14.), and to which I must again refer, you place an object nearer to the eye than that which is already represented, you would find that the rays from this second object will condense into a focus before they come to the retina, and thus be indistinct.

You may ascertain the fact by shutting one eye, and while you are looking with a single eye at any object, as that tree, which is about fifty yards from you, hold a pencil in the same direction, at about a foot distance from your eye, and you will find, that while you see the pencil distinctly, the tree will appear indistinct; but if you adjust your eye so as to see the tree distinctly, then the pencil will appear indistinct.

HARRIET.

The thing is now quite intelligible to me. There is a sort of ill-defined edge on the object to which the eye is not accommodated, which the other is without; and if by any of the means which you mention, the focus can be made to be nearer or more remote, according to circumstances, that is, can be made to be in the retina, instead of within or beyond it, distinct vision will, of course, be accomplished.

DR. A.

I have stated to you that no alteration in the curvature of the cornea takes place, so that the effect is not produced in this way; neither can it be proved that any elongation of the body of the eye occurs, which some supposed could be effected by the pressure of the muscles of the eyeball. A power belonging to the crystalline lens of altering its form, either by some muscular operation, or in

some other way, which is not sufficiently understood, was long considered as that by which the phenomenon could be most readily accounted for. But though the lens exhibited something of a fibrous appearance under the microscope, there seemed to be no sufficient proof of its change of shape to settle the point in question. It was formerly supposed that the ciliary processes might be of a muscular nature, and be concerned in the adjustment of the eye, and at Sir Everard Home's request, Mr. Bauer directed his particular attention to the nature of those substances. By examining them in the field of his microscope, he found that there were about eighty of them; that they were about a quarter of an inch in length; had their origin all round the capsule of the vitreous humour, passed over the edge of the lens, and terminated in its capsule, to which they were attached. Sir Everard infers that these processes are of a muscular nature, that they can contract to one half their length, which is to the extent of one-eighth of an inch, and that by their contraction they can pull back the lens, so as to approximate it sufficiently to the retina, to produce the adjustment necessary.

CHARLES.

This is a very beautiful discovery, but can

microscopic observations be sufficiently depended upon to settle such a difficult question?

DR. A.

There is no question of Mr. Bauer's skill in the use of the microscope, and his accuracy of observation; and, setting aside the difficulties which are connected with the study of organization so minute, there is much appearance of truth in the deductions which Sir Everard has made on this subject.

HARRIET.

You mentioned the cure of opacity in the crystalline lens, by the depression or the removal of the lens. If the patient had the same power as before the operation, of accommodating the eye to different distances, this would be against the idea that an alteration in the form or position of the lens produces the adjustment.

DR. A.

This, however, is not the case; for it has been found after such an operation, that the eye had not the same power which it originally possessed; and that the assistance of glasses is necessary, in order to produce distinct vision at different distances.

CHARLES.

Have any calculations been made of the re-

spective quantities of refractive power possessed by the different parts of the eye?

DR. A.

From experiments made on this subject, it would appear, that the refractive power of

Atmospheric air, is	-	1·00032
Water - -	-	1·3358
The aqueous humour	-	1·3366
The central part of the crystalline lens -	-	1·3990
The whole lens -	-	1·3839
The vitreous humour	-	1·3394

CHARLES.

As there are two images of every object presented to the inward sense, I suppose there is some sort of sympathy or accordance between the two eyes, which enables them to see an object as one, and not two.

DR. A.

And yet you may very readily, by a little management, see the same object, either as one or two. If you put two candles on a table, at different distances from the eye, and in the same line, it is clear that you can see both of them at the same time. Let us try the experiment. Now attend, Harriet, to the further one; how does the nearer appear to you?

HARRIET.

I see two images of the nearer one.

DR. A.

Look next at the nearer candle, and what appearance does the further make?

HARRIET.

I now see two images of the further one.— This is exceedingly curious; but is the same circumstance applicable to all objects seen at different distances?

DR. A.

Certainly so; but the subject does not strike us at once, from the circumstance of the object to which the eye is directed, being the principal, or indeed the only one attended to in ordinary circumstances. A certain power of accommodation of the two eyes to one object, is therefore necessary to correct vision; and many intoxicated persons, or those who have lost the command of their eyes in certain diseases, see objects double.

SOPHIA.

But I cannot understand why, at one time, two images on the retina should give the perception of one object; while, at another, they should give the perception of two.

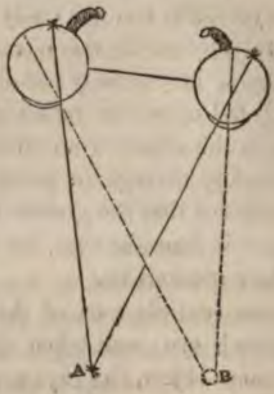
DR. A.

The question is difficult, and has given rise to a

good deal of controversy. In order to understand it, it is necessary to consider some circumstances relative to the motions of the eye. The axis of the eye is a straight line, which is supposed to pass through the centre of the pupil, and of the crystalline lens, and to fall on the middle of the retina: in viewing an object, we turn our eyes in such a way, as that the axis of each eye will, when protracted, meet in the centre of the object. But if we turn one eye to an object, the other is instantly turned to the same object. We cannot move one without the other; and we may feel that if one of the eyes is even shut, it follows the motion of the other, just as if it were open: this is called the paralell motion of the eyes. But you will easily understand, that the natural motion in vision cannot, under any circumstances, be precisely parallel; because the rays which fall upon the retina of each eye, form an angle in the object from which they proceed, and therefore diverge in going to the eye. You will likewise see that the greater the distance is that the object is from the eyes, the more nearly parallel will their motions be.

Now the most sensible part of the retina is at the centre of each eye; and when the eyes are turned to the same object, the rays are necessarily impinged upon such centre, and you have perfect and single vision. But if you press, with your finger, one of the eyeballs, in such a way as that

the rays should not fall upon the centre, then you have double vision produced. There is, therefore, some sympathy or correspondence, whether natural or acquired, between the centres of each retina, by means of which an image falling on both of them, conveys to the sensorium the impression of one object only. The centres of each retina, therefore, *correspond*, as it has been termed, with each other. You will readily understand this, by a diagram, in which two globes, having each the optic nerve at their bottom proceeding from them, represent the two eyes, turned both of them to the object (A).



It is obvious that a straight line from (A) will fall on the retina at its centre, just as far from the optic nerve of the one eye, on one side, as from

the optic nerve of the other eye, on the other. Under such circumstances, distinct and single vision are produced. But if you move the globe of one eye, so as that rays from the object (A) will not pass through the centre of the pupil and of the lens, and will be impinged on the retina of one eye, at some distance from the centre of the retina, while in the other they are impinged on the centre of the retina, then double vision is produced. The rays do not, in this case, fall upon points of the retina which are corresponding.

SOPHIA.

You have made this very intelligible as far as the centre of the retina goes, or the point into which the axis of the eye enters; but then all objects which we view, and every part of the same object, are not at one point; and therefore the impingement must occupy some sensible space of the retina, which must be greater or less, according to the magnitude or number of the objects seen at one time.

DR. A.

If the object (B) be placed at one side of the object (A), and on the same plane, it will be seen single, as well as the object (A); and the rays proceeding from it will proceed to the retina in the direction of the dotted lines.

Now consider under what circumstances single vision is produced. It takes place if the rays are

impinged on the centre of the retina; but it likewise occurs, if rays fall on the retina, at the same side of the centre, and at equal distances from it, as is the case with the dotted line. The centres of the retina, therefore, and such parts of it as are at equal distances from the centre, on the same side, correspond with each other, and are termed *corresponding points*, and if rays fall upon them, single vision takes place.

In the case of the candles seen at different distances, suppose you look at the more distant (B), the candle (C) is seen double, and the images appear as if the objects were at (D D), but the rays fall from the candle (C) on the retina, in the direction of the dotted lines; that is, on opposite sides of the centre of the retina, instead of the same side, and double vision is the consequence.

HARRIET.

When the eye is distorted as in squinting, do people see double? I never heard of this being the case, though it seems as if it should be so, according to the system of corresponding points.

DR. A.

People do not see double in squinting: and it would therefore seem probable, that when the distortion is a very slight one, there has been a power exercised by the eye, of having certain points made corresponding, which were not originally so. This, of course, involves the consideration of whether points were corresponding by an original law of our nature, or by the effects of habit and experience. In general, however, when people squint, the distorted eye is turned so far to one side, as not to receive rays from the object seen by the other; so that, in this case, one eye is for the most part only employed, and double vision of necessity not produced. But it is to be remarked, that a distorted eye is generally weaker than a sound one; and in such a case, the stronger impression of the sound eye is principally attended to: that of the weak is comparatively overlooked; and a distortion spontaneously occurs, in order to cut off the rays, and avoid confusion. — The conjoint operation of both eyes is not merely useful for increasing the strength of impression. In

many instances it likewise facilitates the power of direction, as you will find if you try to thread a needle, or to introduce a stick into a ring, with one eye instead of two.

SOPHIA.

For the sempstress's operation, I flatter myself that I may be some authority; but I am really surprised at the difficulty of hitting the eye of the needle when one eye is shut. I should have been inclined to expect more, rather than less precision with one eye, if the trial had not undeceived me.

DR. A.

There is a remarkable circumstance connected with impingement on the retina, which was discovered by the Abbé Marriotte; it is this, that such rays as fall on the part where the optic nerve enters the eye, and pierces the sclerotic and choroid coats, for the purpose of being diffused over the latter, in the form of retina, is insensible, and presents no image to the mind.

SOPHIA.

This is exceedingly curious. But how can this point be rendered evident?

DR. A.

It can very readily be done; and for this purpose, I shall put three small pieces of white paper on the wall, at about two feet distance from each

other. Now, stand opposite the middle paper, at the distance of four feet, and shut your left eye, holding your finger upon it. Look at the left-hand paper with your right eye. You see the whole of the three portions of paper, though, of course, the left hand one more distinctly.

SOPHIA.

Certainly.

DR. A.

Keep your body in the same position, and retire gradually. You are now about seven feet from the wall, but do you see the middle paper?

SOPHIA.

I do not, though I see each of the others.

DR. A.

Retire a yard or two further back.

SOPHIA.

I now see the middle paper, and both the others likewise; so that it is clear, that the rays proceeding from the middle paper, while I was at the distance of seven feet from the wall, though they fell on the eye, were not actually seen.

DR. A.

The reason of this is, that the optic nerve enters the eye, rather to the inside of the centre of the retina; and when you retired, keeping the eye steadily on the left-hand paper, the rays from the

middle one fell on that part of the eye where the optic nerve enters, as you might easily convince yourselves, by varying one of the diagrams which I have shown you. The third paper is only necessary for greater distinctness; for the same circumstance is equally demonstrable with two portions. But the experiment may be varied, so as to show the insensibility of the same portion of both eyes at the same time. Thus, put two pieces of paper, Harriet, at the distance of three feet from each other on the wall, and retire to the distance of 12 or 13 feet. Keep your eyes on the paper, and hold a finger upright, about eight inches before your eyes, still viewing the papers.

HARRIET.

My finger appears double, the papers single.

DR. A.

Of course; but you will find that there is a position, in which your finger will conceal from the right eye, on your shutting it, the view of the left hand paper; and from your left eye, on your shutting it, the view of the right hand paper. Keep your finger in this precise position, and look at it steadily with both eyes.

HARRIET.

I now lose sight of both papers; so that the rays must have fallen on an insensible part of the

retina in both eyes. But why should this be the case? for I should have expected, that the nerve itself would have been endowed with all the sensibility of the part derived from it.

DR. A.

Philosophers were much puzzled about this circumstance, when it was first known; and some were disposed to consider the choroid coat as the peculiar seat of vision; because it was wanting in this particular spot where the nerve penetrated. But your difficulty is removed by the consideration, that the nerve itself is not the organ of vision, but the expansion of the nerve; and that we might as well expect the nerve, in any part of its course from the brain to the organ; or even the brain itself, as the source of the nerve's energy, to be endowed with visual power, as that the nerve should possess it at this particular place, where the formation of the organ is only to commence.

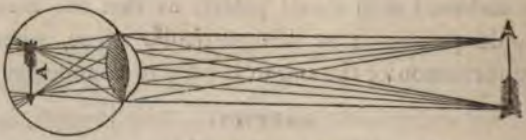
HARRIET.

How beautiful and perfect an instrument must the eye be, when it is considered, that the minutest object of a large landscape is correctly painted on so small a space as the retina must be, with all the vivid colours of nature; but I suppose there are varieties in the perfection of the instrument, or its fitness for producing the due impression on the mind.

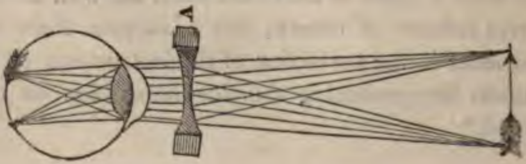
DR. A.

The instrument is perfect when the rays pass through the eye without interruption, and unite in a focus upon the retina. But then, with some, the refractive power of the eye is so great, as produce the convergence on the retina too soon. This is called short-sightedness, or myopism, from mice being supposed to have such kind of sight; whereas, on the other hand, when the rays are not brought to a focus with sufficient readiness, presbyopism, or long-sightedness, is produced.

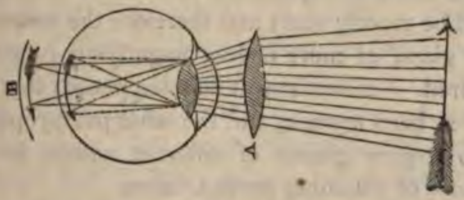
This will be readily understood from a diagram, in which an image is formed at A, before the rays reach the surface of the retina, so that they again begin to diverge; and these diverging rays give the indistinct vision of a short-sighted person.



A double concave lens (A) makes the rays diverge, and thus retards their convergence into a focus to the requisite extent.



In another diagram the rays, as at B, do not converge sufficiently soon, and therefore require the additional refraction which the double-convex lens A affords.



So that, in the short-sighted, the object is to diminish, and in the long-sighted to increase, the refraction exercised on the rays which are admitted into the eye.

CHARLES.

The diminution of the power of refraction in the eye is, I imagine, a symptom of the approach of age.

DR. A.

It is termed presbyopism, from being the common defect of old people, and it is one of the earliest marks of failure in the natural powers. With me, you may have observed, that the nice operation of nibbing a pen, and reading very small print, has, for some time past, required the assistance of a glass. Around the nib of the pen there is a slight confusion, owing to the rays not con-

verging into a focus at the usual distance from the eye, and a glass of slight power removes it; while both in doing this, and in reading small print, the distance at which the focus could be correctly made, would be beyond that at which small objects could be readily seen; and therefore the assistance of a glass, of more or less magnifying power, is required. — Sometimes it has happened, that one eye has been myopic, and the other presbyopic, so as to require glasses of different nature for the purpose of obtaining perfect vision.

CHARLES.

Does the eye lose power in advancing life, independently of the altered faculty of accommodation?

DR. A.

When the nervous sensibility of the eye, that is, the power of the retina to communicate impressions to the sensorium, is gone, or diminished, then blindness, in various degrees, takes place; and one usual consequence is the more or less expanded state of the pupil, and its diminished, or total insensibility to the action of light.

But there is a very singular natural defect in the eyes of some persons, altogether independent of disease; and that is the want of the power of discriminating certain colours. A curious story is told of a Glasgow student, who could not distin-

guish between red and green; so that it used to be a common trick among his fellow-collegians, to throw his red gown (which he wore as a student) upon the grass, in order to enjoy his difficulty in finding it. — Dr. Priestley mentions a case in the Philosophical Transactions, in which a similar difficulty of distinguishing between red and green existed; the person being able to discover cherries on trees, only from their differing in size and shape from the leaves. He could distinguish a difference in stripes; but all light colours he described as white, and dark ones as black. Two of his brothers had defective vision; one of them calling light green, yellow; and orange, the colour of grass. — Dr. Priestley's case was the means of another being brought forward, in which pink and pale blue appeared alike, as did full red, and full green. The person could distinguish all shades of yellow and blue, except pale blue; but full purple and deep blue sometimes baffled him; and claret colour appeared like black. This person's father, one of his sisters, and an uncle on the mother's side, had a similar defect; as had two sons of his sister, but her daughter had perfect vision. — Dr. Nicholl, of Ludlow, has described two curious cases of this kind, which came within his own particular observation. In one of them, a young gentleman of 10 years of age, could not distinguish green; but with the exception of dark bottle-green,

which he called brown, he termed other greens red. Red and blue he could discriminate; but light red and pink he called light blue; light yellow, yellow; and darker yellows, and light browns, he confounded with red. Grass, and green baize, he considered of the same colour; and once said, that he knew fowls were contained in a butter-basket, carried by a countrywoman, from seeing the red feathers hanging out, which proved to be green leaves with which her butter was covered. The only colours which he could discover in the prism were red, yellow, and purple. The young gentleman's maternal grandfather had a similar defect, and being in the navy, once purchased a blue uniform coat and waistcoat, with *red* breeches, to match the blue. Green he always confounded with red. A brother of the grandfather had a similar defect, and has mistaken a cucumber for a lobster, and a green leek for a stick of red sealing-wax. — Dr. Nicholl's second case is nearly similar; grass being always regarded as red, and fruit undistinguishable from leaves, except by the shape; and in no other member of the family had such a defect been known, except in the daughter of a brother.

SOPHIA.

It is very curious that all those cases agree in confounding green with red.

DR. A.

This is a very remarkable circumstance, and it accords with the only case of a want of power of discriminating colours which I ever personally knew, that of a clergyman, who could not distinguish between the red rose, and the green leaves of the rose-bush.

CHARLES.

These cases are likewise interesting, as confirming what you mentioned, relative to the transmission of accidental peculiarities of structure.

DR. A.

Undoubtedly; and the more accidental peculiarities are attended to, the more are they likely to be found appertaining to particular families.

SOPHIA.

You mentioned that the expanded state of the pupil, and its diminished sensibility to light, were connected with a diminished power of the retina, or with various degrees of blindness. The iris, then, I suppose, must be considered as a sort of guard to the internal parts of the eye, to prevent too much light from passing into them.

DR. A.

Certainly; and hence, according to the degree of light, the iris will contract, so as to intercept, or expand, so as to admit light. You may see this

in one of your eyes very distinctly; and when I even hold my hand before Charles's eye, and remove it suddenly, the contraction of the pupil is instantly seen.

In some animals, where there is a necessity for occasional exposure to strong light, there is what is called a membrana nictitans, or winking membrane, which the animal has the power of expanding over its eye, so as to intercept the light, and place the eye, as it were, behind a curtain. When not employed, this membrane lies in the corner of the eye; and it is expanded by means of two muscles, when its protection is necessary.

HARRIET.

I have observed this frequently in the parrot.

DR. A.

It is common to all birds, and is most perfect in birds of prey, with which there is a necessity for looking at, or very near the sun. It likewise exists in cats, and all animals of that genus; in the opossum; in the seal; and in the elephant. There is a rudiment of it in man, at the inner canthus of the eye; and this is still greater in the horse. But in some fish, as the skate and thornback, there is a sort of curtain, at the upper part of the pupil, which is capable of being let down, at the pleasure of the animal, so as entirely to exclude rays from passing through it.

SOPHIA.

The pupil in all animals does not seem to be round. In the cat, for instance, it is oblong, and is capable of extraordinary changes of shape.

DR. A.

It is vertical in some animals, as in those of the cat kind; and transverse in others, as the ruminant animals, horses, &c.; and this sort of construction allows of a more varied contraction and expansion, than by means of circular fibres only; and therefore gives to an animal the power of employing the eyes in very bright, or very obscure lights, with great effect. The contraction or dilatation of the pupil is in some degree under the influence of the will; and with gentlemen who are much in the habit of experimenting with the eyes, the faculty is capable of considerable increase, so much so as to admit of dilatation against light, or contraction in gloom.

CHARLES.

Do you imagine that there is as much difference in the visual faculty in animals, as there is in their smell? I should imagine that this must be the case, if it be true, that birds of prey can discover the animal which they intend to attack at a great distance.

DR. A.

I have no doubt that your idea is correct, for

Nature has very wisely adapted the strength of all the faculties to the habits of the animal. The eyes of the eagle are proverbially acute; and birds of prey generally have extraordinary powers of vision. It is stated in the Philosophical Transactions, by Sir Everard Home, that an hour after a wild hog was killed, in India, and long before there could be the least odour from putrefaction, a dark spot was seen in the heavens, which proved to be a vulture making directly for the carcase of the animal. Soon afterwards, similar specks were seen; and seventy other vultures speedily made their appearance. Dr. Russel states having observed at Aleppo, in serene weather, when not a speck was to be seen in the sky, that if any dead animal was left behind by hunting parties, in the space of a few minutes it was surrounded by birds, although none were visible previously. The eyes of such kind of birds must likewise have a great power of accommodation, since they are equally adapted to great distances, as to the small ones which must intervene between their eyes, and the prey which they attack.

CHARLES.

Where there is the great power of accommodation which you mention, is there any peculiar apparatus for the purpose of effecting it, which man does not possess?

DR. A.

As far as the structures agree, there is every reason to suppose that the same circumstances apply to the human and other eyes; but in many birds there is a rim of scales lying over the junction of the sclerotic and cornea, which has been imagined, but without sufficient evidence, to be concerned in effecting accommodation, by the elongation or shortening of the axis of the eye, according to circumstances. There is likewise, in birds, a point of minute structure, which some have supposed to tend to the same purpose. It is that of a fine membrane, rising in the back of the eye; proceeding, apparently, through a slit in the retina. It forms a sort of fine bag; and being imbued with black paint, like the choroid coat, it is termed the marsupium nigrum, or black purse. It passes obliquely into the vitreous humour, and terminates in that part, reaching frequently to the capsule of the crystalline lens.

SOPHIA.

As the medium occupied by fish must be nearly of the same density as the aqueous humour of the eye, one would imagine that the latter would be useless as a refracting organ.

DR. A.

You are very right; and therefore in fish, and some quadrupeds and birds which are much in

the water, as seals and cormorants, the crystalline lens projects through the iris, so as to leave very little room for aqueous humour; for in them it would evidently be of no use. But in order to make up for the want of this as a refracting medium, the crystalline lens in fish is more of a sphere than is usual in the other classes, and thus has a greater refractive power. On the other hand, in birds, which spend much of their time in a somewhat elevated region, where the medium is rarer than at the surface of the earth, the aqueous humour is in considerable quantity.

Fish have been described by some physiologists, as having a small muscular organ connected with the choroid coat, the use of which is to assist in accommodating the eye to different distances. You may thus see, however, that much as is known about the eye, a great deal is still to be ascertained relative to its minute structure.

CHARLES.

You mentioned the great power of dilatation, which the oblong shape of the pupil affords to animals which have occasion to use their eyes in obscure lights; but is mere dilatation of pupil sufficient to enable them to see in the dark?

DR. A.

This will only go to a certain extent; but there is a curious provision for seeing in the dark, which

such animals have, and that is, that the inner membrane of the choroid coat, instead of being covered, in its inner surface, wholly with the black paint which I have mentioned as belonging to it in man, has a greater or smaller proportion of it of a pearly white, or of a yellow, green, blue, or variegated colour, by means of which there is a reflection, instead of an absorption of rays, from the bottom of the eye. In the cat, and animals of the cat kind, which prowl about at night for their prey, this is eminently the case; and their eyes occasionally glare in the dark, when the pupil is much enlarged, by the reflection of light from the lucid covering which I mention, and which is called the tapetum lucidum or lucid carpet. Horses have kewise a coloured, instead of a black surface, and they are thus enabled to see their way in the dark, when their riders are at fault: this is also the case with cows, sheep, dogs, and various other quadrupeds; but birds are without it, as are fish, with the exception of the skate; and this is rather remarkable, for it might be imagined that fish would have occasion for every means of increasing light, in pursuing their prey, or in looking out for an enemy at great distances, and at vast depths.

HARRIET.

But are we to suppose the faculty of seeing durring the day, diminished by animals being endowed

with such a peculiarity of organ, as enables them to see in a superior manner during the night? For as the total darkness of the interior of the human eye is advantageous to it, as an optical instrument, and is well adapted to its seeing well in ordinary light, one would imagine that the same must be the case with the eyes of other animals.

DR. A.

There is certainly a difficulty in the point which you mention, that has not been altogether cleared up; for though some of the human race who have the peculiar defect of sight which is called night vision, and see best at night, see imperfectly during the day, yet some of the animals which I have named to you, particularly the cat, have very keen vision as well by day as by night. It is very possible, however, that the eye of man may derive the accuracy and precision which fit it for the particular examination of minute objects, and which are unnecessary in other animals, from the impingement of rays on the retina being unaffected by reflection from the neighbouring choroid. — We have been lately informed by two eminent French physiologists,* that in fish which require to see well in the depths of the ocean, and in such birds as have occasion for accurate vision at great distances, there is an amplification and extension of both the retina and

* MM. Magendie and Desmoulins.

optic nerve in the interior of the eye, by means of a sort of fold or doublings, which give a greater extent of sensible surface, and therefore augment the power of this organ of vision.

I must not omit to notice to you, the very remarkable eyes which are possessed by insects, and which are so unlike any which exist in the higher orders of animals. Some insects have simple eyes, that is, eyes which seem composed of a single lens; in others, these simple eyes are collected into a body, and these have been termed conglomerate. But the most extraordinary are the compound eyes, which are those possessed by most insects, and which, with the glass, present an appearance resembling shagreen. This arises from the eye being traversed with numerous dark lines, cutting each other at right angles, and forming little squares, within each of which is set a six-sided convex lens. The inside of these lenses is covered with a black varnish or paint; and behind this, are minute white threads, of the shape of hexagonal prisms, which fit into the groove formed by the sides of the hexagonal lens, and are separated from the latter by the black varnish. The threads are inclosed in a black unvarnished membrane, on which the optic nerve is expanded, and from which they are derived; so that they may be regarded as the retina of the eye, and the dark membrane, as the choroid coat. But it is difficult to

perceive in what way vision is produced by an impingement on a retina, having black paint interposed between it and the rays which are to be the subjects of observation. If you examine the head of a fly with a pocket glass, the appearance of shagreen will be very apparent.

HARRIET.

It is quite evident, but I cannot make out the lenses which you describe.

DR. A.

This is owing to the black paint which lies below them; but here is the head of a dead fly, divided in such a way, as to separate the shagreen surface from the parts below. On placing this in the field of my little microscope, and throwing some light upon it, you will have the brightness of the lenses well defined.

HARRIET.

Beautifully so; but they seem to be rather shining points than to possess any well described figure.

DR. A.

This is from the power of the instrument not being quite sufficient to give you the full effect of this appearance, and of the shape of the hexagonal prisms of nervous matter, which I have mentioned

as being continued from the lenses, and which appear as slender, light coloured threads.

SOPHIA.

But what a number of these little lenses there must be. They seem to be innumerable.

DR. A.

They vary in different insects, some have very few, not more than fifty; but Hooke computed those in the eye of a horse-fly to amount to nearly 7000; Leeuwenhoeck found more than 12,000 in that of a dragon-fly; and still more have been observed in the eyes of butterflies. It is to be presumed, that the number and minuteness of those lenses are necessary to that microscopic nicety of vision, which insects must have, in order to provide food, and avoid injury. As their eyes, too, are without motion, a structure such as that which I have now mentioned, was wanting for the reception of rays from all directions. — The appearance of the opaque substance below these lenses, produces the beautiful metallic hues, for which the eyes of some insects are remarkable.

The remarks which I have made relative to the eye, refer principally to it as an organ of vision; but there is much curious structure external to the eye, for the purpose of giving it motion, and affording it protection. — For the first purpose, six

muscles arise from different parts of the orbit, and are implanted into the sclerotic coat, which produce the varied movements of which the eye is capable. In order to protect the eye, the eyelids are, in the first place, the principal agent. These have a ready motion, and a peculiar watchfulness and sensibility, so that they, and the edge of hair by which they are bordered, and which are called the cilia, or eyelashes, continually guard the eye from the introduction of irritating matters from without.

HARRIET.

The tears are produced, I suppose, for the purpose of washing out any irritating substances which may get into the eye?

DR. A.

This is not the only use for which they are intended, for they also serve to keep the eye moist. They are secreted from a gland known by the name of the lachrymal gland, which lies under the orbit, at the upper and outside of each eye. The secretion from this gland is continual, even during sleep; and is carried to the surface of the eye, by several small ducts or tubes, which open upon the inner surface of each eyelid.

HARRIET.

But then if the secretion of tears is continual,

how does it happen, that the eye is not perpetually weeping? In the day-time, evaporation might be supposed to carry off the superfluous fluid; but during sleep, when the eyelids are closed, this could not take place.

DR. A.

Your question is a very pertinent one, and I shall explain to you how this occurs. The eyelids are edged by cartilage or gristle, which keeps them regularly expanded, and allows them to shut closely upon each other; but this accurate approximation is only on the fore-part; for behind, there is a small conduit, which conducts the tears to two small orifices, called puncta lachrymalia, or lachrymal points, one situated at the extreme inner edge of the upper, and the other at that of the lower eyelid. You may see, by careful examination, a small point on each eyelid, which are the points mentioned by me.

CHARLES.

You mean at the very projecting part, where the rudiment of the nictitating membrane commences.

DR. A.

Exactly so. These orifices have cartilaginous margins, so as always to keep open. They are thus ready for absorbing the tears, and are so

small, as to act by capillary attraction, that is, as you may recollect, by the particular property of very small tubes, of sucking up a fluid without any particular external agency.

SOPHIA.

But then where are the tears carried to?

DR. A.

These orifices lead, by two small ducts, into a little sack or cavity, of a longitudinal shape, which terminates in a duct, opening into the cavity of the nostrils, where the fluid is diffused over an extensive surface, and evaporated by means of the air passing continually over it. When these ducts, leading from the eye to the nose, are ob-

structed, the eye becomes weeping, and that particular complaint is produced, which is known by the name of fistula lachrymalis, or lachrymal fistula. You will be able to understand this from a little sketch, which I now show you, in which *a* is the lachrymal gland; *d d*, the lachrymal points; *e e*, the lachrymal ducts; *f*, the sac; and *g*, the duct leading into the nose.

CHARLES.

How very beautiful is all this contrivance; and indeed a little consideration might convince us of the communication between the eye and the nose, when we find that a considerable portion of fluid is thrown into the cavity of the nostril in weeping; and that this secretion is increased by any irritating substance getting into the eye. But how is the eye, which is so sensible to ordinary irritation, and the passages which you have mentioned, guarded against the continual agency of the saline fluid, the tears?

DR. A.

This seems to be, by the secretion from the various surfaces to which they are applied; and in the case of the eye-lashes, by a sebaceous or fatty matter, secreted by small glands, situated under the inner membrane of the eyelids, and having tubes, through which their secretion is carried to their cilia or edges, which are, by this means, kept fit for accurate approximation. These glands

are the seat of sties in the eye; and when their secretion is much increased, as in inflammation of the eyelids, the eyes are often nearly glued up by their increased secretion.

HARRIET.

One would imagine that animals which live in water, and have, therefore, the eyes kept always moist, would not require tears, as those who live in air do.

DR. A.

And therefore they are without any part of the apparatus for secreting them; for nature, while it does not withhold proper accommodation, gives no organ which is unnecessary or useless.

SOPHIA.

The motions of the head seem to be well calculated to assist the eyes, and to enlarge the sphere of vision; but I suppose the eyes have their position directed by nature, according to the wants and character of the animal.

DR. A.

Certainly: in man, and some other animals, the eyes are placed chiefly to look forward, but at the same time so as to take in nearly a whole hemisphere. In birds, their lateral position enables them to embrace almost a sphere, in order the better to assist them in discovering food, and announcing

danger. In hares and rabbits, the eyes are not only very prominent, but are placed so as to look behind as well as before, and thus to see an approaching enemy; while dogs, whose habits are rather to pursue than to avoid, have their eyes set more forward in their head. — I have already mentioned the immensity in number of the eyes of many insects. Spiders have no motion in their heads, and have four, six, or eight eyes, to increase their sphere of vision, which are placed in every variety of form in different species. The snail has four, but they are inserted at the extremity of their horns, the motion of which enables them to be turned in all directions. The lobster likewise has no motion in its eyes, but they are situated at the end of two moveable peduncles, so as to be turned in various directions.

There is an interesting circumstance relative to our appreciation of the direction of eyes, which I must not omit to mention to you before I take leave of vision. We are sensible, of course, when the eyes of any person are fixed upon us; and we have a perception of the exchange of even a momentary glance.

SOPHIA.

Assuredly.

DR. A.

But in what way do we form this opinion?

SOPHIA.

By observing that the eyes are directed to or from us?

DR. A.

This is no doubt the case; but then is it by means of the eye itself, or by the relation which the eye bears to the other features, that we come to this conclusion?

SOPHIA.

I should think the eye itself must give us the necessary information; for it is to this that the attention is particularly directed: though I must own I have never made this a subject of particular remark.

CHARLES.

One is certainly very apt to conceive, that the eye may be contemplated separately from the other features; but yet it would be difficult, if not impossible to do so; and you therefore stagger my confidence in my first apprehension as to the facts of the case.

DR. A.

It has been proved by Dr. Wollaston, who is one of the most distinguished philosophers of the present day, that if a pair of eyes be drawn with correctness, looking at the spectator, unless some touch be added to suggest the turn of the

face, the direction of the eyes seems vague, and so undetermined, that their direction will not appear the same to all persons. If to such eyes particular features be appended, they may be made to appear directed either to him, or from him, in a manner perfectly unexpected. Dr. Wollaston, therefore, infers, that as in the portraits of eyes, we judge of the direction by the concurrent position of the entire face, we do the same with regard to the eyes of living persons. He exemplifies his doctrine in a manner equally ingenious and satisfactory, by some sketches, annexed to his paper in the Philosophical Transactions for 1824, p. 260. To a pair of eyes, with the eyebrows drawn from the life, by Sir Thomas Lawrence, intently looking at him, a turn of face was added, so that the eyes, with this accompaniment, appear decidedly looking at the spectator, though indistinctly so without it. By means of a flap, a set of features oppositely turned, are so applied to the same eyes, that they look considerably to the right of the person viewing them.

HARRIET.

How exceedingly curious this must be; it would be hardly possible to believe them to be the same eyes.

DR. A.

No one would, unless with complete evidence

of their identity; and in four other sketches of the same eyes, two of them have their apparent direction altered by the mere position of the nose; and in the others a corresponding difference is effected solely by means of the upper half of the face. The same would happen if the eyes, instead of being drawn originally looking directly at us, were made to look a little to one side of us; in which case they might be made to look at us, by applying other features in a suitable position.

CHARLES.

But I presume this very striking effect is limited to small differences.

DR. A.

Certainly, to changes of perhaps 20 or 30 degrees; for, as Dr. Wollaston remarks, it would be absurd to imagine, that an eye drawn in profile, could be made to look full on us; or that an eye looking nearly at us, could be made to appear as profile.— But Dr. Wollaston likewise observes, that a total difference of character may be given to the same eyes, by a proper representation of other features; and that a lost look of devout abstraction, in an uplifted and interesting female countenance, may be exchanged for an appearance of inquisitive archness, merely by giving to the face a direction downwards, and to the opposite side. I must refer you to the original paper, for

CONVERSATION XII.

OF THE ORGANS OF SENSE.

HEARING.

DR. A.

The next of the organs of sense which I intend considering, is hearing, which is the sensation communicated to the nerves of the ear, principally by means of vibrations of the air transmitted from the sonorous body. These vibrations, or undulations, are collected by the external ear, in a sort of trumpet-like tube, at the extremity of which is a cavity called the drum of the ear, or the tympanum, which is filled with air, and is covered by a membrane called the membrane of the tympanum. The undulations act on this membrane, and through its means on a curious bony structure situated in its cavity; while the impressions are, by the last bone of the series, propagated to what is termed the internal ear, which consists of several small cavities, filled with water, and having the delicate terminations of the auditory nerves diffused over them.

CHARLES.

There seems, therefore, to be the same plan followed by nature in the arrangement of the auditory, as of the visual functions; the more external parts being destined to receive and communicate impulses from without, to the more internal parts, which are the immediate organs of sense.

DR. A.

The funnel-like tube, and the irregular surfaces of the outer ear, collect and concentrate the undulations of the air, so that they may act with greater force on the membrane of the tympanum. The external ear, in most animals, has also a considerable agency in this operation; for its concave surface is placed, at the will of the animal, in the direction from which sound proceeds, in order to intercept a greater portion of the waves or undulations. Among the more civilized nations the ears are so much tied down, as entirely to lose the power of motion.

SOPHIA.

But do you suppose that we should have the power of moving our ears like dogs or horses, except for this early habit of binding them down?

DR. A.

Certainly not to the same extent, because the

ears are neither of a similar size nor shape; but some eastern nations have a considerable power of motion in theirs; and in some ancient statues they project considerably, which adds to the expression of the head. Many people have the power of producing an obscure motion in the ears; and in all, a muscular structure is plainly discoverable by dissection; there being a muscle for raising the ear, another for carrying it forward, and two for carrying it back.

HARRIET.

Bitter wax is, I suppose, intended to prevent insects from making their way into the tube of the ear?

DR. A.

It is designed for this purpose; as are likewise some small hairs which stand across the passage. The wax will sometimes increase to such an extent, as to occasion deafness, by plugging up the passage, and thus preventing the propagation of the vibrations of the air to the membrane of the tympanum. The obstacles to the entrance of insects are wisely intended; for the internal passage is so very sensible, as to be capable of much pain and injury in case of irritation.

HARRIET.

The undulations which you mention as occurring

in air, are somewhat similar, I suppose, to what take place in water, when put in motion.

DR. A.

Certainly; and though they are not visible, as in water, they may sometimes be felt in tremors on paper held in the hand, by the agitation of the air derived from a loud sound, which would not otherwise have affected the organ of touch.

CHARLES.

The passage of sound is, of course, very much affected by wind acting in an opposite direction.

DR. A.

Not so much as you would imagine; for the velocity of air in the strongest wind is not equal to more than the twentieth part of the velocity of sound, and cannot, therefore, under any circumstances, affect it more than in that proportion.

CHARLES.

But is the celerity of sound the same under all circumstances of strength and weather?

DR. A.

It has been found that sound travels about 1142 feet in a second, or about a mile in 4½ seconds, or 13 miles in a minute. Its velocity is the same whether it is strong or feeble; the sound of the

human voice, or the report of a cannon: but in summer, when the air is not so dense as in winter, sound travels rather more rapidly; so it does in elevated situations; while in cold foggy weather its progress is retarded. The difference in no case is, however, more than a few feet; and in a denser atmosphere, though the progress of sound is retarded, the same sounds are stronger than in thinner air. This, together with the quiet of night, appears to be the reason why sounds are heard better at this season. I may remark, however, that some late experiments in Holland, in the East Indies, and at Woolwich, make the velocity of sound rather less than what it is usually considered to be.

SOPHIA.

The knowledge of the velocity of sound will, in many instances, I suppose, inform us of the distance of a body producing it.

DR. A.

Certainly; and that very readily: for if you see a flash of lightning, or of a cannon, or discover the elevation of an arm making a stroke, you can, in any such instances, by ascertaining the number of seconds which intervene between seeing the flash and hearing the sound, by means of a stop-watch, make out the distance of the thunder-cloud, of the cannon, or of the man. A very ready

mode of accomplishing the same thing, is by an observation of the pulse, which ordinarily beats about 75 times in a minute. With a small allowance, the number of beats intervening between the light and the report, will indicate the distance with sufficient accuracy for ordinary purposes, particularly if by means of a stop-watch the rate of the pulse be ascertained. Making each pulsation as equal to 1000 feet of distance, you would be sufficiently near the truth.

HARRIET.

But is air absolutely necessary to the propagation of sound, or are there other substances which will answer the same purpose?

DR. A.

It is necessary that sound should have some material by which to be propagated; for experiments show, that in the exhausted receiver of an air-pump, sound is very much deadened, and becomes louder on re-admitting the air, though it is, of course, still a good deal diminished by the interposition of the glass. Water, however, communicates sound very well, and so does any solid body, though the readiness with which the communication takes place, is much connected with the nature of the material. Sounds which are made in water, and heard in air, are pretty much the same as if they were made in air, and heard

in water. In both cases the tone is about a fourth deepened: but the velocity with which sound passes through water has not been ascertained, though the sound of a large hand-bell, under water, was heard very distinctly and strongly, by the late Professor Robinson, of Edinburgh, when his head was plunged in water at the distance of 1200 feet.

CHARLES.

But it would be difficult to make an experiment of this kind, so as to be unequivocal in its results, because the sound from the bell would travel to the ear both by the water and the air.

DR. A.

Much care and attention must be necessary in making any experiments of this kind, and I wonder that the subject has not been prosecuted. — A piece of timber will communicate a sound from one end to the other instantaneously, or very nearly so; for experiments have been made by the union of deal rods, to a great length, and the velocity has been calculated to be more than three miles in a second. The approach of cavalry may be heard at a greater distance, when the head is in contact with the ground, than by attending to the sound communicated through the air; and waggons will often communicate a slight impulse to the furniture of a house, before we hear the noise which imme-

diately occasions it. Dr. Young tells us, that the blow of a hammer on a wall, at the upper part of a high house, is heard as if double, by a person standing near it on the ground, the first sound descending through the wall, the second through the air.

CHARLES.

I should think it not unlikely that the same might be the case in the experiment with the bell under water.

DR. A.

Not improbably; and if your law studies admitted of your being an experimentalist, this would be a good subject for a debût. — There are some substances which communicate sound better than others; for instance, a voice can be heard at a greater distance over water than land; and in a still day a whisper has occasionally been heard across the Thames. You may readily ascertain, on any long brick wall, in a quiet evening, that a very low voice or a loud whisper may be heard at the distance of between 300 and 400 feet. I have heard it at the extremities of a wall, not far from us, of above 400 feet long.

I mentioned to you, that the sound is impelled upon the membrane of the drum, which is very thin and sensible, and, through its medium, on a bony structure, contained in the cavity of the

drum. This bony structure is exceedingly curious, not only in itself, but in the names of its different parts; for they are termed the malleus or hammer; the incus, or anvil; the orbicular bone; and the stapes, or stirrup.

CHARLES.

But is there any real resemblance in these bones to the things from which they are named?

DR. A.

A good deal, as you will perceive from the annexed sketches, which represent these bones considerably enlarged.


Malleus, or Hammer.


Incus, or Anvil.


Orbiculare, or Orbicular Bone.


Stapes, or Stirrup.

The connection which these bones have with each other, you will be able to apprehend from another little sketch, in which A is the bony margin of the opening into the ear; B is the membrane of the tympanum; C the malleus fixed to it, and attached to the incus D; E the orbicular bone; and F the stapes.

The undulations of the air act, as I have already mentioned, on the membrane of the tympanum; this propagates an impulse to the malleus; the malleus to the incus; and the incus to the orbicular bone and the stapes. These bones are all in the drum of the ear; but the last-named, the stapes, is fixed to a membrane, covering a hole, called the oval hole; and this membrane, like that of the tympanum, conveys to the parts within, the vibrations which the latter carries to the bony structure.

CHARLES.

Then are these bones put in motion by the vibrations of the membrane of the drum?

DR. A.

It is supposed that they are; and this is exceedingly likely, as they are provided with muscles, which answer for the motions which would be produced in this line of propagation. — Connected with the drum of the ear are some little cavities in the substance of the bone, contiguous to the ear, and which are called the mastoid cells, and are supposed to have some influence in increasing sounds.

CHARLES.

You mentioned that the cavity of the drum is full of air; by what means does it obtain entrance? For, if I understand the structure of the drum right, it is totally impervious.

DR. A.

The membrane of the drum is impervious; but in its cavity is an opening, which is the termination of the Eustachian tube, a tube so called from Eustachius, its discoverer, which opens in the posterior part of the mouth. It is through this opening that the air is supplied, and fills the drum of the ear and the cells communicating with it.

SOPHIA.

Then I dare say it is, in some degree, by this opening that hearing is assisted; for people are apt, in listening, to open their mouths, as well as direct their ears.

DR. A.

There is no doubt of this being the case; and hence we find, in sore throat, that severe pain is occasionally propagated to the ear, from this tube becoming inflamed. If it is obstructed, too, deafness is produced, because there is a difficulty in the impressions being carried on from the tympanum, in consequence of there being no yielding behind it, as is the case when the air has free ingress and egress. Hence, in such circumstances, a small opening in the drum of the ear has been found useful in restoring the proper action of the parts. Many doubts were entertained as to the propriety of making such an opening; but at last its safety was demonstrated by Sir Astley Cooper, more than twenty years ago, and the Copleian medal of the Royal Society adjudged to him for the enterprise. — The stirrup, I mentioned to you, is connected with a membrane covering the oval hole. This membrane separates the drum of the ear from another small cavity, called the vestibule; and with this vestibule, other cavities, called the semicircular canals, and the cochlea, proceed, both which, together with the vestibule, are, from their involved and irregular shape, known by the general name of labyrinth. These parts form the proper organ of hearing; for over the lining of the whole of the cavities which they form, the auditory nerve is diffused; and in

order that the impulse propagated from the drum and bones of the ear to the actual organ of sense may be as forcible as possible, the whole of these cavities are lined with a watery fluid, which is, as it accurately fills them, admirably adapted for giving effect to impressions from the bones of the ear. The various ramifications of the cavities increase, in a small space, the nervous expansion devoted to hearing; though the particular reason for the peculiar shapes of these cavities is not known. There is one point, however, worthy of notice with regard to the labyrinth; and it is this, that Nature has been so careful of losing nothing in the way of impulse, that she has made a second opening into the internal ear, from the tympanum, which is called the foramen rotundum, or round hole, and is covered with a membrane. This, it is obvious, will admit of a slight degree of movement propagated from the impulses on the membrane of the oval hole, through the medium of the fluid contained in all the cavities above mentioned, and thus the nervous expansion will be more surely acted upon. It is a matter of difficulty to comprehend this complex structure without an attentive and accurate examination of the parts themselves; but it will be rendered a little more intelligible by a sketch.

In this you will recognise the malleus, incus orbicular bone, and stapes. This last is attached, to the membrane of the oval hole, which opens into the vestibule, the central compartment of the sketch. The semicircular canals are towards the right; and the cochlea, so called from its resemblance to a snail's shell, towards the left. A small canal leads from the cochlea up to the tympanum, from which it is separated by a membrane covering the round hole. These various ramifications of the labyrinth form, therefore, the proper seat of the organ of hearing, to which the other parts are only subsidiary.

CHARLES.

I have heard of some persons who are able to puff out tobacco-smoke from their ears. I can easily understand that this must reach the ear by means of the Eustachian tube; but in what way

can it escape from the ear, since there is no opening naturally in the membrane of the tympanum?

DR. A.

Whenever this happens, it must be through an artificial opening in the tympanum, which now and then occurs in complaints of the ear. It can never take place in the healthy state of the organ.

CHARLES.

You have informed us that in one particular cause of deafness, that of obstruction in the Eustachian tube, an artificial opening made in the membrane of the tympanum will restore hearing; but I cannot understand how the destruction of this organ by disease is compatible with the continuance of the power of hearing. I should think the internal parts would be so destroyed, before it could happen, as to take away hearing altogether.

DR. A.

Not to the extent which might at first be imagined; for as long as the more internal parts of the ear are unaffected, some degree of hearing will still remain, even if some of the bones are destroyed, or come away by ulceration. This indicates that the proper organ of hearing is the labyrinth; and, indeed, in some animals there is no introductory tympanum, and no bones of the ear; but the undulations of the air are received at once

on a membrane which communicates them to the fluid, and thus to the nervous expansion of the internal ear. If however in man, or those animals which have a tympanum, the last bone of the series, the stapes or stirrup, is destroyed, the membrane filling up the oval hole will be lost also; and as the fluid contained in the inner ear will in consequence escape, deafness will ensue, from the medium being lost by which the immediate organ of hearing becomes affected. It is to be observed, however, that the bones of the head are able to communicate impressions to the organ of hearing without the medium of the air, or the aid of the external ear. Thus a watch touching the forehead is heard with great distinctness, if the ears be entirely stopt; and so is the sound of water boiling, by means of a poker touching the vessel, and taken between the teeth; or that of a tuning fork, or any other sounding body taken between the teeth.

HARRIET.

The auditory faculty must, I suppose, differ a good deal in its acuteness in different individuals, for some persons have very nice ears for music, and others can hardly distinguish one note from another.

DR. A.

There is a great deal of difference between that power of perception which constitutes hearing,

and that which is connected with the appreciation of musical sounds. The former is a faculty which is possessed by mankind very much in common; the latter varies exceedingly among different people; but it appears from some new observations of Dr. Wollaston, that some persons are insensible to various sharp sounds, as the chirp of the house-sparrow and house-cricket, the squeak of the bat, and the noise of small insects, without having any other defect in the organ.

HARRIET.

There must be very little known, then, I presume, about the circumstances which occasion a nice ear in music.

DR. A.

In that we are very much in the dark; for though Sir Everard Home has shown a muscular structure in the membrane of the tympanum, both in man and other animals, particularly the elephant, and considers this structure, by means of the different degrees of tension which it is capable of producing in the membrane, mainly conducive to the formation of a musical ear, yet as it has been ascertained, that a musical ear can be retained after the destruction of the membrane of the tympanum, this opinion is not tenable. Sir Astley Cooper observed in a case, in which the

membrane of the tympanum, in both ears, had been destroyed, that the hearing was but little affected; and that the person had an acute perception of musical sound, and sang with taste, and perfectly in tune.

HARRIET.

Do animals differ much in their powers of hearing, as it appears that they do in their faculties of vision?

DR. A.

We do not know much of the comparative acuteness in the auditory faculty in animals; but the elephant is said to be endowed with a remarkable sense of hearing, and its auditory organs are larger than in other animals, or man. Mr. Corse, who saw much of the habits of the elephant in India, and communicated some valuable information on the subject, to the Royal Society, gives some examples of their acuteness of hearing. He states that a tame elephant, which was never reconciled to have a horse moving behind him, although he expressed no uneasiness if the horse was within his view, either before or one side, could distinguish the sound of a horse's foot, at a distance, some time before any person in company heard it. This was known by his pricking up his ears, quickening his pace, and turning his head from side to side. He also mentions a tame female

CONVERSATION XIII.

OF THE ORGANS OF SENSE.

TOUCH.

DR. A.

In the account which I gave you of the integuments, I mentioned that the skin is plentifully supplied with nerves, to which it owes its peculiar sensibility. — This sensibility is diffused generally over the whole surface, and forms the principal means by which we become acquainted with many of the properties of substances, as heat, cold, hardness, softness, solidity, figure, extension, and motion. But though the SENSE OF TOUCH is diffused over the whole body, the fingers are more particularly endowed with it; and hence it is by them that we more particularly examine the qualities of external bodies.

HARRIET.

I have heard that man owes a great deal of the powers of discrimination which he enjoys in his hands, to the peculiar position and strength of his thumb.

DR. A.

I have no doubt of this being the case, for the thumb is a very important organ in the examination of the form of bodies; and though the monkey tribe, or quadrumana, have hands a good deal similar to those of man, yet their means of becoming acquainted with the properties of bodies is less complete than ours, from the thumb being weaker, shorter, and less easily brought to meet and oppose the fingers: for you may observe that it is by opposing the thumb to the fingers, that we seize and examine the most minute bodies, with the greatest accuracy. There is likewise this important difference, that we have the power of separating, and acting with the fingers separately, which monkeys have not, from wanting the particular muscles necessary for the purpose. — There are little elevations of skin called villi, from their supposed resemblance to the pile of velvet, on which the minutest ramifications of nerves and blood-vessels are diffused, so as to impart to them the utmost sensibility. This sensibility may be diminished by disease, or in some rare cases entirely lost; and though the diminution of sensibility is generally connected with a diminished power of motion, yet this is not always the case, as I have already had occasion to notice.

SOPHIA.

You mentioned that the proboscis of an elephant

and the snout of a hog are the organs of touch in those animals: I suppose that every living creature has some particular part of its body to which it owes the sensations of touch.

DR. A.

Most animals have organs of touch more or less perfect. In the ruminant animals, and horses, the lips or tongue seem to answer this purpose, as does the upper lip in the rhinoceros. The whiskers of animals of the cat-kind serve the same end, the bulbs of these hairs being largely supplied with nerves. The combs of cocks and turkeys give those animals feelings of touch; and geese, ducks, and other animals which seek their food much in mud, have their bills covered with a very sensible skin, which is supplied with an abundance of nerves. The tails of some animals have an extraordinary prehensile power, by means of which they can seize any thing as with a hand.

CHARLES.

But how imperfect must all those modes of examination be, to the nice organs possessed by the human race, by means of which our examinations into the properties of bodies are so minute and effectual.

DR. A.

For the purpose of their nature, the organs of touch in animals are sufficiently well adapt-

ed; and in particular for assisting them in their appreciation of danger, and in their search after, and discrimination of food; but the hand of man is so superior in the nicety of its formation, as well as in the acuteness and diffusion of its sense of touch, to any thing which is possessed by other animals, as to have been termed by Aristotle, the instrument of instruments; and to have been regarded by some philosophers, and in particular by Buffon and Helvetius, as one of those organs to which we are mainly indebted for our superiority over the inferior animals. Buffon carries his notions so far, as to suppose that one man may excel another in genius and ability, only because he has earlier had the unrestrained use of this sense, which the practice of swaddling in another, though carried on merely for six or seven weeks after birth, would interrupt. He also supposes, that the sagacity of animals is greater in proportion as their organs resemble those of man; and that hence the hand of the ape, and the trunk of the elephant, make these animals superior to all others. Helvetius even goes so far as to consider it not admitting of a doubt, that if nature had terminated our wrists by the hoofs of a horse, instead of flexible hands and fingers, we should have been, at this time, wandering in the forest like wild animals.

HARRIET.

What a humiliating and degrading idea! These philosophers seem entirely to put aside the intellectual part of man, that high glory and distinction, by which he is approximated in nature to the great Being to whom he owes his existence.

DR. A.

Whatever may be the nice adaptation of the parts of animals to the various functions which they have to perform; however they may even seem to exceed the human race in the perfection of some of their organs, yet man has nobler faculties than those of mere animal existence, by which he is placed at an immeasurable distance above the other races which inhabit the earth. Even if he had hoofs instead of hands, and were otherwise constituted as at present, he would still, as Mr. Dugald Stewart well observes, be man, in possession of all the faculties and powers which are characteristic of his nature, and capable by experience, and the resources of his own mind, of making up, in part, for so material a defect. — There are many examples of people born without arms, who have been able, by means of their eyes, feet, and toes, by their teeth, or by other parts of their body, to make very useful exertions, and to acquire, indeed, great expertness in various

mechanical employments. Persons have been repeatedly exhibited, who could use scissors very adroitly with their toes; and some have been described, who could discharge a pistol with them, thread a needle, write, and even comb their heads, and take off their hats. One man is living near Exeter, who is without arms or shoulders, and yet can exercise many of the duties of a farmer. He is able to lift great weights with his teeth; can catch, saddle, and bridle his horses, and do various domestic offices with his feet; and can feed, dress, and shave himself, and write with his toes. He has been twice married, has ten children, none of whom have any natural defect; and has, occasionally, battles with other men, in which he runs furiously at his adversary with his head, tripping up his heels at the same time.—But one of the most interesting examples of this kind, as you may remember, is that of a young woman, who had neither legs nor arms, and yet could sew, write, and draw.

HARRIET.

I perfectly recollect seeing her five or six years ago: her name was Beffin; and we all thought she was destitute of legs, though we were not quite certain, and did not like to make any inquiries which might be uncomfortable to her. In working with her needle, she employed her mouth, tongue,

and teeth; together with a small stump, which extended four or five inches below the shoulder; and in writing and drawing, she guided, with her mouth, her pen or pencil, which were fixed by a sort of loop to the stump of the right side.

DR. A.

In all these examples, there is a directing and an ennobling principle, of which the brute creation is destitute, and the want of which makes it preserve, age after age, the same relative position in the scale of existence. Man, therefore, is not the wisest of animals (as a great ancient physician observed), because he possesses hands, but hands are given to him because he is the wisest of animals; for it is not by his hands, but by his reason that he is instructed in the arts.

There is a very important circumstance connected with the sense of touch, which is the assistance that it gives to vision. When we consider that our perceptions of visible objects arise from a picture of such objects falling upon the retina, we know that our sense of vision merely communicates to us a picture of a certain magnitude, and of certain varieties and shades of colour. If we did not know by touch, the forms of these bodies, and were not acquainted with their particular shades, and apparent magnitudes at different distances; if we were ignorant that there were differences of shade,

answering to the different prominences and depressions of objects, the picture of the retina would merely be that of a flat, coloured, and unmeaning surface.

SOPHIA.

But are we not sensible, when we view a picture of any object, though we know that it is a flat surface, that it represents objects of various shapes and forms, and that by the different shades and different magnitudes, objects at various distances are depicted?

DR. A.

Certainly; but then we have the previous knowledge which enables us to form such conclusions. Let us take, for example, the pillar on which the dial-plate is fixed. Of what shape and size is it, what is its distance, and of what material is it constructed?

SOPHIA.

It is round, to be sure; about a foot in diameter; made of stone; and at about a dozen yards' distance.

DR. A.

The answer seems easy, but how do you come to these conclusions?

SOPHIA.

Why surely there can be no doubt of my correctness as to these points?

DR. A.

There is none as to your correctness; and no philosophy is required to communicate the information; but how do you know that it is round?

SOPHIA.

I see that the light and shade are placed in a particular manner; and even if a flat body were so painted, it would give the impression of a round one.

DR. A.

Unquestionably it would; but if you had not, by feeling the pillar in question, or other round bodies, become acquainted with what roundness is, and had not known that roundness was invariably characterised by certain shades of surface, you would have known nothing about the matter. The size you judge of by comparison with other bodies of known dimensions; that is, such as you have either touched, or compared with others which you have touched. You obtain a knowledge of distance, because distant objects are not so vivid as when near; and then their images bear certain relations, in perspective, to other bodies of known magnitude. The material, stone, you know by handling it; and when you have once seen, and touched it at the same time, the feeling of hardness, coldness, roughness, or polish, as the case may be, are immediately brought to your mind,

and give all the requisite information whenever you see the particular substance again.

SOPHIA.

Then, in fact, it would appear, that we have every information of this kind to learn: at what period does our education commence? It must begin in the nursery, for I am sure that our little Eleanor knows the shape of the pillar as well as we do.

DR. A.

Have you never observed what delight an infant takes in handling bodies which are brought near it; and as it grows in strength and intellect, how readily it recognises objects, and how correctly it recollects previous impressions? The whole of early life may be said to be a period of education, of that species of education which masters would in vain supply, which nature has placed within our own power, and which is obtained by the spontaneous exercise of our faculties.

HARRIET.

This is very wonderful, but yet very reasonable; but what would be the circumstances of a person who suddenly regained his sight (if we could suppose any such) with regard to external objects? he would have no previous means of comparing the perceptions of sight and touch, and

would therefore have to learn their relations to each other, before he could know that the white-shaded surface of the pillar related to the object which we know to be the actual body.

DR. A.

He certainly would; and I am happy in being able to communicate to you a very celebrated case from Cheselden, a distinguished surgeon, who died about 70 years since, which throws much light upon this subject. It is that of a young gentleman, who was born blind, or lost his sight so early, that he had no remembrance of ever having seen, and was couched between 13 and 14 years of age. He was never so blind as not to be able to discern day from night, and in a strong light to distinguish black, white, and scarlet; but he could not perceive the shape of any thing; nor did he know, when he was able to see, that the colours which he could distinguish in a strong light before the operation, were the same as those which he saw after it. When he first saw, he was so far from being able to judge of distances, that he thought all objects whatever touched his eyes (as he expressed it), as what he felt did his skin; and thought no objects so agreeable as those which were smooth and regular, though he could form no judgment of their shape, or guess what it was in any object that was pleasing to him.

He knew not the shape of any thing, nor any one thing from another, however different in shape or magnitude; but upon being told what things were, whose form he before knew from feeling, he would carefully observe, that he might know them again; but having too many objects to learn at once, he forgot many of them; and (as he said) at first he learned to know, and again forgot a thousand things in a day. One curious particular Mr. Cheselden mentions. Having often forgotten which was the cat and which the dog, he was ashamed to ask; but catching the cat, which he knew by feeling, he was observed to look at her steadfastly, and then, setting her down, said, "So, puss, I shall know you another time." He was very much surprised, that those things which he had liked best, did not appear most agreeable to his eyes; expecting that the persons would appear most beautiful, whom he loved most; and such things most agreeable to his sight, that were so to his taste. It was thought that he soon knew what pictures represented which were shown to him, but this was afterwards found to be a mistake; for about two months after he was couched, he suddenly discovered that they represented solid bodies, when to that time he considered them only as party-coloured planes, or surfaces diversified with variety of paint. But even then he was no less surprised, expecting the pictures would feel like the things

they represented; and he was amazed when he found those parts, which by their light and shadow appeared now round and uneven, felt only flat like the rest; and asked which was the lying sense, feeling or seeing? Scarlet he thought the most beautiful of all colours; and of others, the most gay were the most pleasing; whereas the first time he saw black, it gave him great uneasiness, yet after a little time he was reconciled to it; but some months after, seeing by accident a negro woman, he was struck with great horror at the sight. Being shown his father's picture in a locket at his mother's watch, and told what it was, he acknowledged a likeness, but was vastly surprised; asking, how it could be that a large face could be expressed in so little room; saying, it should have seemed as impossible to him, as to put a bushel of any thing into a pint.

At first he could bear but very little light, and the things which he saw, he thought extremely large; but upon seeing things larger, those first seen he conceived less, never being able to imagine any lines beyond the bounds he saw. The room he was in, he said, he knew to be but part of the house, yet he could not conceive that the whole house could look bigger. Before he was couched, he expected little advantage from seeing, worth undergoing an operation for, except reading and writing; for he said he thought he could have no

more pleasure in walking abroad, than he had in the garden, where he could do so safely and readily. And even blindness, he observed, had this advantage, that he could go any where in the dark, much better than those who can see; and after he had seen, he did not lose this quality, nor desire a light to go about the house in the night. He said every new object was a new delight; and the pleasure was so great, that he wanted words to express it; but his gratitude to his operator he could not conceal, never seeing him, for some time, without tears of joy in his eyes, and other marks of affection: and if he did not happen to come at any time when he was expected, he would be so grieved, that he could not forbear crying at his disappointment. A year after first seeing, being carried upon Epsom downs, and observing an extensive prospect, he was exceedingly delighted with it, and called it a new kind of seeing. And after being couched of his other eye, he said that objects at first appeared large to this eye, but not so large as they did at first to the other; and looking upon the same object with both eyes, he thought it looked about twice as large as with the first couched eye only, but not double, as could in any way be discovered.

HARRIET.

This is really a very important and interesting

narrative, and it serves to place, beyond a doubt, the means by which we come to a knowledge of external nature. I shall not be so anxious, in future, to prevent an infant from handling objects of its attention, since it is a species of lesson which it is giving to itself, and which is necessary to its proper education.

DR. A.

You must take care, however, that the disposition to assist its studies, is not purchased at too dear a rate; for you must recollect, that a child makes no distinction between a wooden, and a glass cup, as far as the chance of destruction goes; and that it is very long before it obtains sufficient knowledge and caution, to have all the trustworthiness of Harriets and Sophias.

CHARLES.

Have no confirmations been made of Cheselden's interesting observations, during the long period that has elapsed since his operation was performed?

DR. A.

You must observe that cases of the kind mentioned by Cheselden are very rare; for in the first place, cataract is a complaint which very often takes place after vision has been enjoyed for a long period previously; and when it has been born with

a person, the operation may have been performed before the age at which the necessary observations could be satisfactorily made. It may likewise happen, that the blindness was less complete than in Cheselden's case; and last of all, that both observer and patient may be less acute and intelligent, than is necessary for accurate observation on so difficult a subject. A similar case was described some years since by the late Mr. Ware; but as the observations made relative to it, did not altogether correspond with those of Cheselden's boy, though there was reason to suspect a greater degree of vision than in his case, and therefore a less fitness for correct deduction, some degree of doubt was thrown on Cheselden's interesting history, which for 80 years previously had been unquestioned. There has been lately published, however, by the ingenious Mr. Wardrop, in the Philosophical Transactions, the particulars of a case which agree, in the most important points, with Mr. Cheselden's narrative. In this case, a lady of 45, who was born blind, had, when about six months old, her right eye entirely destroyed by the effects of an operation which was made for her relief at Paris. An operation was likewise performed on the left eye, but without success; and it appears that owing, perhaps, in some degree to this operation, a contraction, and in time a complete obliteration of the pupil took place, with the

power of distinguishing a very bright light only. This state of things existed when Mr. Wardrop saw her; the fore part of the eye, or cornea, being transparent; but the rays being unable to penetrate into the interior of the eye, from the pupil being shut up by the iris expanding like a curtain over it. The operation necessary for her relief, was therefore to take out a small part of the centre of the iris, and thus to make an artificial opening or pupil in it, which might allow the light to pass through the eye, and be impinged upon the retina. After three operations, the sight was restored, and she found herself in possession of an entire new sense. The first object which she remarked, was a hackney-coach, when she asked what large thing it was that had passed: she was much amused with various objects which were presented to her; and enquired whether some oak-coloured doors, on the opposite side of the street, were red. She asked what a handkerchief was, which her brother threw over his face, and complained of being bewildered with the new objects, and disappointed in not distinguishing at once by the eye, objects which she could so readily discriminate from one another by feeling them.

She often asked what things were; and could form no idea what an orange was, on the chimney-piece, till she touched it. On being told that it was port wine which her brother was drinking, she

said it looked to her very ugly; and when she was informed that the shining edge of a japanned tray was yellow, observed (as Cheselden's boy did of the cat), 'I shall know that again.' On being taken out of the house, she was surprised and delighted with every thing; but particularly admired the blue sky, which she said was the prettiest thing which she had yet seen, and was equally pretty every time she turned round to look at it. She was confused with the multiplicity of objects, and excited the observations of bystanders, by the manner in which she stared at every thing. Reflection of bright light was unpleasant and startling. She was sensible of the different impressions from colours, and soon learnt their different names; preferring yellow, and then pale pink. She had much difficulty in directing her eye to an object, and finding its position; moving her hand, as well as her eye, in various directions, as a person when blindfolded, or in the dark, gropes with his hands for what he wishes to touch. Sometimes when an object was held close to her eye, she would search at a distance for it; and at others, feel close to her face for a thing far removed from her. When a pencil-case and a key were put into her hands, she knew each distinctly; but on being laid on a table before her, she could not tell which was the one and which the other. She could distinguish large from small objects; the

upper from the lower part; saw objects erect; and could perceive motions; but on her leaving London, 42 days after the last operation, she found that she still had a great deal to learn.

CHARLES.

It is very gratifying to find Cheselden's case thus confirmed; for I have heard doubts entertained of its correctness, though the results were exactly what had been foretold would happen, under the circumstance of a person born blind, suddenly recovering his sight. Locke, I recollect, states that Mr. Molyneux, on being asked whether if a metallic cube and sphere, the shapes of which were previously known by touch, were placed before a person who suddenly regained his sight, he would know the one from the other, was of opinion that he would not, and in this Locke agreed with him. Mr. Wardrop's experiment of the pencil-case and key is quite decisive of this point. — I presume that persons who have been unfortunately deprived of vision, particularly at an early period, have their other senses, and especially their hearing, rendered much more acute, in order to make up for the defect.

DR. A.

It is wisely ordained by Providence, that there is a compensation given for most of the corporeal

defects which occur to us. We have seen this exemplified when the limbs have been wanting; and it is very strikingly so with the blind, whose hearing, power of touch, and faculty of general observation, become much more nice and accurate than in ordinary circumstances.

There are many examples on record, of blind men acquiring great facility in conducting themselves about, and in discriminating external objects. An instance is mentioned in the Manchester Memoirs, of one John Metcalf, who, though blind, was able to find his way, when the ground was covered with snow, over the most intricate roads. Singular as it may appear, he was employed as projector and surveyor of highways in difficult and mountainous parts; and was in this capacity greatly distinguished. With the assistance only of a long staff, he was able, in a way peculiar to himself, and which he could not well explain, to make his observations and designs in the most satisfactory manner.

Dr. Saunderson, formerly professor of mathematics at Cambridge, was one of the most splendid examples ever known of high acquirements in the blind. His knowledge in mathematics was very profound; and his lectures were remarkably clear and intelligible. His sensation of touch was so very acute, that he was able to distinguish, merely by running his fingers over them, between a ge-

nuine antique and a counterfeit medal. He had a similar faculty to that which I have already mentioned on the subject of hearing, in distinguishing the distances of bodies; and he could recollect places pretty exactly, by the sounds of pavements, and the reflection of sounds from walls. He was a distinguished musician, and his ear was so nice, that he readily was said to be able to discriminate the fifth part of a note of music.

Dr. Moyes was likewise remarkable for his acquirements in Natural Science, and for his excellence as a lecturer, though he lost his sight by the small-pox in infancy. He could, from early life, use edged tools with great dexterity; and made little windmills, and even a loom. His power of discriminating sounds was exquisite, both as to the size of rooms, the number of persons which they contained, the height of those with whom he talked, and other minute particulars. He had a certain perception of very vivid rays, when refracted through a prism; and from red rays derived disagreeable sensations, which he compared to the touch of a saw; while the green were agreeable to him, and conveyed to him the same idea as that which was produced by running his hand over smooth polished surfaces. He excelled in the charms of conversation, and was happy even in his allusions to visual objects.

CHARLES.

I should imagine that the memory, in the blind, must acquire a great additional power of retention; for there must be a great many minute circumstances to recollect, in all the pursuits in which blind persons excel, of which those who see can have no idea.

DR. A.

They are cut off from all objects which distract the attention, and have, therefore, the power of making their sensations more the subject of remark, and of having them more deeply impressed on the memory, than those who see.

HARRIET.

How greatly are the blind objects of our sympathy. The countenance owes so much of its character and vivacity to the eyes, that one cannot but feel an indescribable melancholy in the contemplation of the vacant countenance, and the rolling unmeaning eye of a blind person. The beautiful and plaintive lines of Milton well depict the pensive state of mind to which the want of sight gives rise, in those who have once known its enjoyments:

> " ———— Thus with the year
> Seasons return, but not to me returns
> Day, or the sweet approach of ev'n or morn,
> Or sight of vernal bloom or summer's rose,
> Or flocks, or herds, or human face divine."

DR. A.

And yet there is such a charm in human intercourse, that it certainly admits of a question, to which organ we owe most of the enjoyments of life, the eye or the ear. If a person is born blind, the hearing and other organs, as we have seen, make up in a considerable degree for the defect; if he is born deaf, he is also dumb, and thus is entirely cut off from the greatest blessing of life, social intercourse, the interchange of sentiments and feelings, to which man owes so largely, his most noble and characteristic enjoyments. But what would you say to the privation of two senses, hearing and seeing?

SOPHIA.

One can hardly conceive a state of things so desolate: but have any instances of so unfortunate and pitiable a state of existence been known?

DR. A.

Condillac and Diderot have speculated on the knowledge of external objects, which could be obtained under the want of one or more of the different organs of sense; and many of their suppositions are sufficiently probable: but a case of a very extraordinary nature occurred some years since, which put some of their hypotheses to the test. It was that of a young man, named James Mitchell, the son of a clergyman in the county of

Moray, who was born not only blind, but deaf. The circumstances of this case are so peculiar and so interesting, that I shall give you the details of it at some length; referring you to the 7th vol. of the Edinburgh Philosophical Transactions for the original account *, by the very distinguished Mr. Dugald Stewart.

This poor fellow was born in 1795, is described as being athletic and robust, having an intelligent countenance, and as being one of a large family, in whom there were no corporeal defects. His mother very early discovered that he was blind, from his shewing no desire to turn his eyes to the light; and that he was deaf, from no noise, however loud, being capable of awakening him from sleep. Very early in life, he used to be much pleased with striking a key, or any thing else, which communicated a sharp sound, upon the teeth; but his principal gratification seemed to consist in sitting for an hour at a time, opposite to a small hole in the south wall of an outhouse, so as to receive, directly upon his eyes, the beams of the sun, which shone through the chink during a part of the forenoon. He was likewise pleased with the bright light of candles; and derived great amusement from concentrating the sun's rays on his eyes, by means of pieces of glass, transparent

* See also Mr. Stewart's 3d. vol. of the Philosophy of the Human Mind, and the Edinburgh Review for 1812.

pebbles, or similar substances. But though he had perceptions of light, he derived little or no assistance from his eyes, as organs of vision. His most pleasurable sensations were from taste and smell, and he eat with great voracity; but he received great pleasure also from the sense of touch, applying substances to the tongue, in order to feel their surfaces more accurately, and employing himself frequently, for many hours together, in selecting from the bed of a river, which runs within a few yards of the house, stones of a round shape, nearly of the same weight, and having a certain degree of smoothness. When visitors arrived, who were most frequently males, he discovered the circumstance by smell, and first ascertained whether the stranger wore boots: if he did, he immediately quitted the room, went into the lobby, secured, and accurately examined his whip, went to the stable, and handled the horse with much attention. If there was a carriage, he would examine the whole of it with great attention, and try carefully the elasticity of the springs. On one occasion that his desire to visit the stable had been thwarted, he contrived to lock the servants into the kitchen, in order to be allowed to accomplish his visit.

He contrived to make known his wants by a sort of natural language. If he were hungry, he touched his mother or sisters, and pointed to the

place where the victuals were usually kept. If he wanted dry stockings, he pointed to his legs; and upon one occasion, when shoes that were too small for him were put away into a closet, he took them out of the closet, and put them on the feet of a young lad who attended him, whom they fitted exactly. When sick or feverish, he used to point to his head, or to put his mother's hand opposite to his heart. He expressed satisfaction or complacency by patting the person or object which excited this feeling; rage, by bellowing; and great pleasure by laughter. He was most readily managed by his sister, who notified her wishes to him by the different degrees of force, and different manners with which she touched his head. New clothes were his greatest delight. After his measure had been taken, every hour was full of anxiety, till the new suit was in his possession. He persecuted the tailor or shoemaker until his shoes or ooat were finished, and was their guest, morning, noon, and night, till the last stitch was drawn. Tearing his clothes was the usual expression of his anger; and nothing was a greater punishment, than being obliged to wear them when torn. He obtained, by careful examination, a certain range around the house, in which he walked fearlessly, and gradually felt his way into new ground. On one occasion, he was seen creep-

ing across a narrow foot-bridge, at a place where the stream was deep and rapid: but he was prevented making any further attempts of a similar kind, by being plunged once or twice into the river, as soon as he was secured. During the cure of a wound on his foot, it was usually rested on a small footstool. More than a year afterwards, the boy with whom he used to play, met with a similar accident. As soon as he discovered this, which he did from the boy being stationary, and having bandages on his legs, he went up to a garret, sought out the little footstool, and bringing it in his hand to the kitchen, quietly placed the boy's foot upon it.

He went to church, and conducted himself reverently; but was without any appearance of religious feelings. He was attached to his family; assisted the farm servants in some of their duties, as cleaning the stable, and endeavoured to repair breaches in the farm houses, and to build houses with turf. Some attempts were made to improve his sight; but though at first promising, there was at length a complete failure. In a subsequent communication to the Royal Society of Edinburgh in 1815, by the late esteemed Dr. Gordon of Edinburgh, a few further particulars are given, and an account of some unsuccessful attempts which were made for his instruction.

SOPHIA.

You have interested us exceedingly, by the history of this poor boy, who seems so much cut off from communication with the external world; yet he has amusements and gratifications.

CHARLES.

Have no recent accounts been heard of him? Such a remarkable case should not be lost sight of.

DR. A.

I have been surprised that, since the account which was given of him in 1815, so long a period should have elapsed without his being noticed to the public; and it was only the other day that I was gratified by seeing, in the third volume of Mr. Stewart's Elements of the Philosophy of the Human Mind, just published, a letter from Miss Mitchell, addressed, in August last, to Sir Thomas Dick Lauder, of Relugas, in which the account of the brother was brought up to that time. — I shall mention to you the principal circumstances which are noticed in it, some of which, it appears, were stated in previous letters to the late Dr. Gordon or Mr. Stewart, which have been mislaid. After an escape which he had from drowning, he did not for a long time visit the sea-shore; but as his recollections became fainter, he gradually resumed his

rambles on the beach, but never entered into any of the boats.

He was once thrown down by the leaders of the mail-coach, but not hurt. Ever afterwards, however, he bolted aside whenever a carriage was approaching. He is fond of smoking, and has a regular supply of tobacco and pipes, 2 pipes and $\frac{1}{3}$ of an ounce of tobacco per day; and never expects his allowance except at fixed times. Once he broke his pipe before the time for receiving a new one, and taking a halfpenny, which was in a cupboard, brought it and the broken pipe, with a supplicating air, to his sister; but she made signs for his replacing the halfpenny, as she knew how dangerous it was to relax, in the least degree, from the precision of her dealings with him. He was much displeased by her non-compliance; but got a present of a pipe from an out-door friend, which put him into good humour.— His mother, during her life-time, used now and then to indulge him in little things which his sister refused; and he was in the habit, therefore, of making an appeal to her, when disappointed in his applications to Miss Mitchell. He knows, however, that it is in vain to expect, now, any compliance with his capricious wishes; and if, at any time, he has asked for any thing out of the common run (which seldom happens), and been refused, he takes the first favour-

able opportunity of getting over his displeasure, and becoming friends with his sister again.

For some time after the loss of his mother, he seemed to experience the fear of losing his sister also; and when at any time she got away from home, he instantly went round every part of the house in quest of her. He is continually anxious to secure her personal services, and will wait till a servant is out of the way, to get his pipe lighted, or have any other little office performed by her; and in case of his sister's absence, will reserve all his little repairs till her return. He walks about fearlessly in all directions, many miles from home; is much amused with the various occupations of workmen in Nairn, the town where he now lives; and will climb ladders, and mount scaffolding without dread, and hitherto has done so without accident. He makes himself at home every-where; and is so inoffensive, that he is allowed to enter every house, and handle every thing at pleasure. All classes seem to contribute to his safety and amusement; and only on one occasion did he ever meet with a rebuff, and that was at a house which was occupied by strangers, who were quite unacquainted with his situation. He was very suspiciously, as the family thought, handling the umbrellas in the lobby, and as they got no reply to their remonstrances on the subject, they turned him out by the shoulders; not without difficulty, however, for

he gave them all the kicks and blows in his power. He was terribly annoyed at this incident, and was seen, just after the occurrence, by two gentlemen, bellowing with rage, and not to be pacified.— He does not now like the confinement of church, and though he accompanies his sister a little way on the road, he gently declines carrying the bible, which he used to do when he wished to accompany her.

CHARLES.

How much the poor fellow is indebted to the kindness of his sister, for a great deal of the little enjoyment of which he is capable. It is quite delightful to see how she devotes herself to his service: he may be said to exist in her sympathy and attachment.

DR. A.

Sir James Macintosh had a long interview with them some years since; and in a letter to Mr. Stewart, feelingly, and elegantly observed of Miss Mitchell, that the habitual exercise of ingenious benevolence seemed to him to leave its traces on her naturally agreeable features, and to give an expression more delightful than beauty.

CHARLES.

I cannot conceive in what way the poor fellow can so readily find his way about the country in all directions. He is not described as using a

stick, or feeling his way; and yet it must be by the acuteness of his sensations of touch, that he is principally guided, as he is destitute of any assistance from hearing. He is represented as at first having laboriously explored a small space around the house, which he then walked over fearlessly; but now he seems to be able to go many miles from home without preparation.

DR. A.

This particular point does not appear to have attracted sufficient attention. Smell may have some effect in assisting him; but touch, I should imagine, is the principal agent. I hope, however, that his amiable sister, or some of his discerning friends, will direct their particular observation to his mode of appreciating the positions of places, and those inequalities of surface which he must continually meet with. In the instance in which he turned aside at the approach of a carriage, it is clear that the vibration from the earth must have been communicated very sensibly to his body, and given him warning of the object which he wished to avoid.

HARRIET.

The want of one sense is an essential privation, though it is often made up by the greater perfection of those which remain; but that of two seems

to shut out almost every avenue to comfort and enjoyment.

DR. A.

But if you supposed a person, in addition, born without the sense of touch, he would, it is clear, have no conception of the shape, or of any other of the external characters of bodies, any more than of their visual appearance. Imagine, likewise, the sense of smell deficient, by which he could ascertain the neighbourhood of certain bodies, giving out certain exhalations; and the power of distinguishing, by taste, the flavour of any thing received as aliment, you would leave to him hardly an avenue of connection with the world in which we live. Man, therefore, from the earliest period of life, imperceptibly becomes acquainted with external nature; and by the proper employment of his corporeal functions on the one hand, and of his mental faculties on the other, he acquires an elevation to that high rank in the creation, which Providence has assigned to him.

SOPHIA.

Have the lower animals any means of compensation for defective organs, as is the case with man?

DR. A.

It is not improbable that this may go to a certain small extent; but on this it is exceedingly

difficult to form an estimate. It cannot go far, however, for it is in a great degree by the powers of reasoning, co-operating with the senses, that man is able to make up for any deficiency which he may have, either by accident or nature; and you have seen this remarkably evinced in the proficiency which various persons have made in mechanical arts, notwithstanding the want of hands.

CHARLES.

And yet there seems to be a faculty in animals, which approximates to reason in man; for when a well practised horse measures the height of his leap, and will not attempt what exceeds his force and ability; and while an old grey hound leaves the fatiguing part of the run to the younger, and places himself so as to meet the hare in its doubles, it cannot be denied that they enjoy a reasoning faculty, to a certain extent.

DR. A.

Animals unquestionably possess the powers of external perception and memory, and they likewise exhibit judgment, which is strikingly exemplified in the instances which you have given; and some of them are remarkable for the attachment which they have to individuals of the human race. In these circumstances they resemble man; but without going into metaphysical subtleties, their great discriminating characteristic seems to be

the strength of instinct, by which they are instructed by nature in all that is necessary to their existence, while man requires experience, and is largely endowed with the faculties by which he can gain it.

SOPHIA.

It is curious that animals should come more perfect, if one may so term it, out of the hands of their Maker, than man himself.

DR. A.

But this is an acknowledgment of the higher faculties which man possesses, and which give him the means of obtaining knowledge and experience for himself. — Young partridges and grouse, when they come from their shells, are able to move about among corn, grass, or heath, without the apparent necessity of any experience as to the distances of what may be injurious, or not. Chickens, as soon as they are hatched, can run about in all directions, and can make their way in a straight line to grains of corn, even at the distance of several yards, while man has to gain accuracy of vision by long experience. In the early periods of the history of society, the lord of the creation was obliged to be contented with a rude hut, or a natural excavation for his habitation; but the bee could build its cells with all the mathematical precision of which it is now capable, the bird its nest,

and the beaver its subterranean dwellings, at the first creation of the animal, as well as at present. One of our greatest poets, makes man the imitator of animals, when he says,

> "Thy arts of building from the bee receive,
> Learn of the mole to plough, the worm to weave,
> Learn of the little nautilus to sail,
> Spread the thin oar and catch the driving gale."

Instances of instinct are numberless in the animal creation. — There is a wonderful example of instinct in the migration of birds, which find their way over unknown regions by the unerring guidance of nature. The same is likewise the case in the ascent of fish up almost insurmountable obstacles, to deposit their spawn in secure places; and in the position which insects select for their eggs, for the purpose of insuring proper nourishment to the young, as soon as they require it; and in short, there are none among the infinitely numerous races of animals which inhabit the earth, that do not afford beautiful examples of that instinct, to which, in so material a degree, they owe their existence and their support. Of certain variations in the application of their instinctive powers, animals are capable; and Huber's delightful works on bees and ants, and Kirby and Spence's Entomology, contain many examples of this kind; but still these powers are complete at first, and depend in no degree, as in man, on the operations of experience.

HARRIET.

It is pleasing, in contemplating animals, to consider them as having discrimination and intelligence. The dog, which is our companion, and the horse, which contributes in so many ways to our gratification, would not be half so interesting and amiable, if we did not consider them capable of attachment, and having something of our own feelings in them.

DR. A.

There is an interesting anecdote, mentioned by Holcroft in his Memoirs, of the attachment which race horses sometimes have to the boys who take care of them. These boys (and Holcroft was early in life one of them), sometimes fall asleep in the stalls, from fatigue; and in such cases, the horses will not lie down for fear of injuring them; and you know that our old chesnut is so fond of the stable cat, that he will take her up in his mouth without hurting her; and she is continually lying upon his back as a place of ease and comfort.

CHARLES.

What do you think of Locke's story of the speaking parrot, or rather Sir William Temple's, as quoted by Locke?

DR. A.

That the parrot was certainly a very conversable

animal, and much cleverer than either Leibnitz's dog, or the most learned of the learned pigs.

SOPHIA.

I should be curious to hear something of this extraordinary animal.

CHARLES.

It was a parrot which Prince Maurice saw at Brazil 150 years ago, that spoke, and asked, and answered common questions like a reasonable creature. The prince conversed by means of an interpreter, as the parrot could only speak Brazilian. The prince asked him at his celebrated interview, where he came from. He answered, "From Marinnan." "Who do you belong to?" "To a Portugueze." "What do you do there?" "I look after the chickens." The prince laughed, and said, "You look after the chickens?" "Yes, and I know very well how to do it;" making a chuckle four or five times, as people do who call poultry to them. The prince's chaplain, who was present, could never bear the sight of a parrot afterwards, for he thought they all had a devil in them.

HARRIET.

And what was the story of Leibnitz's dog?

DR. A.

This was an animal that was taught all the letters of the alphabet except m, n, and x; and would

repeat them, and about thirty words, including Thé, Caffé, Chocolat, Assemblée, after his master, a German peasant, who had employed several years in giving him these accomplishments. It is difficult to conceive, however, that the organs of a dog could admit of such appropriation; and Mr. Steward is therefore of opinion, that it was by means of a species of ventriloquism on the part of the master, that the public, and Leibnitz among the rest, were imposed upon in this instance.

It has been said that monkeys, when they have lost their teeth, have learnt to crack nuts with a stone; and an elephant at Exeter 'Change, when a shilling was placed near a partition, but beyond the reach of the animal's trunk, blew hard against the partition, so as to bring the shilling within its grasp. You have all heard of the monkey that made use of the cat's paw to reach the roasting chesnuts; and a story is told by a French philosopher, of a monkey that was chained so as not to be able to reach some nuts of which it was very fond, that snatched a napkin from a servant who was passing, and made use of it to draw the nuts to him. He broke them by letting a stone fall on them; and once when the weather was wet, and the nuts sunk into the ground, he accomplished his purpose by placing a tile under them.

Notwithstanding, however, the sagacity which has been exhibited by various animals, the faci-

lity with which they may occasionally be taught, and the power of accommodation which they can sometimes exercise, yet the most sagacious of them, the monkey, has never been known to keep up a fire, the warmth of which it enjoyed, by throwing a faggot upon it; nor the dog, though the witness and partaker of our cookery, to broil a single portion of raw meat.

CONVERSATION XIV.

OF THE PREPARATION OF THE FOOD.

DR. A.

It is now my intention to give you some information with regard to the mode in which the animal body is nourished, and you will find that a very extended and important system of organs is devoted to this object. The functions of circulation and of respiration, I may observe to you, are carried on by means of organs situated in a cavity, which is called the chest, or thorax; and those which are concerned in the preparation of the food, and in nutrition, in a cavity beneath, called the cavity of the abdomen. The chest is occupied principally by the heart, and the lungs; the abdomen by the stomach, the intestines, the liver, the spleen, and the pancreas or sweetbread. These two cavities, or bags, are separated by a partition called the diaphragm, or midriff, which is partly of a fleshy, and partly of a membranous nature, and readily gives way, by its laxity, to the alternate ex-

pansion and contraction of the chest in the action of breathing, to which its muscular power eminently contributes. The STOMACH is the first of the organs connected with digestion; but previously to saying any thing of its nature or functions, it is necessary to state to you how the food is prepared for being taken into it. The stomach is connected with the mouth by means of a long tube, which is called the œsophagus, or gullet, and receives the food from the mouth; but the first action to which the food is subject is mastication, or chewing, and for this purpose, man, and most other animals, are provided with TEETH, which differ in their nature according to the habits of the animal, and the particular description of food which is intended to nourish it. The subject of the teeth requires particular elucidation, and will form the business of our present meeting.

SOPHIA.

But have all animals not teeth? I should have thought that the dividing of food, which is requisite with us, would be equally so with other animals.

DR. A.

With other animals using the same kind of food it is so; but then we shall see that when nature has not given teeth fit for grinding, she has other resources in the stomach itself, for that sort

of preparation which it is necessary that the food should undergo, previous to digestion. Birds, for example, have not teeth; and with various other animals, as fish and serpents, the teeth seem to be only adapted to prevent prey from escaping, which is swallowed whole.

SOPHIA.

I cannot conceive how an animal, swallowed whole, can ever become adapted to nourish; for with us digestion would be impeded, I should think, if we were not to employ our teeth.

DR. A.

And yet you may have heard of *bolting*, which is employed in some parts of England, especially when the more rancid and fat meat is employed. To bolt bacon, it is said, is one of the requisites of a farmer's servant in Yorkshire. I have already, however, mentioned, that the power exercised by the stomach, is connected with the greater or less preparation which the animal is able to give to the food previous to its introduction; and of this I shall have occasion to give you examples, when on the subject of digestion.—The nature of the teeth depends on the nature of the food which the animal is intended to employ; namely, whether it is animal, vegetable, or of a mixed nature. Animals which live upon animal food are called car-

nivorous; those which live upon vegetable food are called graminivorous; and those which live on both, or either, are omnivorous, a term exceedingly well adapted to man, who is to be reckoned among the most luxurious of this class. By the inspection of the teeth, we are therefore able to form an opinion as to some of the most material habits of an animal.—The teeth which first exhibit themselves are called milk, deciduous, or temporary, from their being intended to continue only a few years, and then to be parted with. Those which supply their places when they are shed, or which appear later, and are not shed at all, are termed permanent.

The teeth in man are composed of two parts; a bony, which constitutes the body of the tooth, and is in nature very similar to real bone; and a bright, smooth, thin external covering, called the enamel. The part which is out of the jaw is called the crown and neck; while the fangs, or roots, are planted deep in the jaw. There is a small cavity in the body of the tooth, which descends in the form of a small tube into the fangs, and contains the vessels and nerves which were employed in the original formation, and subsequently in the nutrition of the tooth. In the vertical section which I now show you of a tooth with two roots, A is intended to represent the enamel of the tooth; B the bony part, or body; and C the cavity,

extending into the fangs, and apparent in a small hole at the points of each.

SOPHIA.

But is not this the mode on which all teeth are formed?

DR. A.

The other omnivorous animals have teeth of a similar structure; and such is likewise the case with the carnivorous; but in the graminivorous, the enamel descends into the body of the tooth, and by forming several perpendicular layers, enables the tooth to resist, much more than it would do if made of bone merely covered with enamel, the attrition necessary in mastication; for the enamel would soon be worn off, and then there would only be the softer substance of the tooth remaining.

CHARLES.

I see that we are able to distinguish between the teeth of the graminivorous animal, and those of the other two descriptions, by the enamel cover-

ing the teeth, or descending into the body of them; but are there differences likewise between those of the carnivorous and the omnivorous animals?

DR. A.

In carnivorous animals, the teeth all fit into each other very nicely, when brought into contact; whereas, in the omnivorous, there is a certain latitude of motion admitted, for the operation of grinding the food.—The *temporary* teeth, in the human race, are 20 in number, and are divided into three kinds; the front, incisores, or cutting teeth, of which there are 8, namely, 4 in each jaw; the canine teeth, dog teeth, or cuspidati, which are 4 in number, one on each side of the incisores, and are of a pointed or conical form; and the grinders or molares, from mola, a mill, which amount to 8, being 2 back teeth, above and below, on each side. The *permanent* teeth are 32 in number. There are, as in the temporary, 8 incisores, and 4 cuspidati; 2 bicuspidati, or two-pointed, next to the cuspidati on each side, amounting to 8; and 3 molares on each side, above and below, making 12, of which the 4 hindermost are denominated dentes sapientiæ, or teeth of wisdom, from their not appearing till adult age.

HARRIET.

But how does it happen that there is occasion

for two sets of teeth; and that the number which we have in the second set is greater than that of the first? I thought that where a tooth was shed, we merely gained another in its place.

DR. A.

There is a very great disproportion between the magnitude of the jaw in the young and adult; and as the teeth, from their nature and mode of growth, do not admit of any increase of size, it was necessary, when the jaw became larger, that a supply of larger teeth should be given. Hence a second set was afforded. But still this was not sufficient for filling up the lengthened jaw; and as youth advanced, some teeth were therefore provided far back, which did not exist in early life; the last supply of which, in the wisdom teeth, does not, as I have already stated to you, take place till adult age, some time after all growth in the jaws has terminated.

CHARLES.

I should be very curious to know from you, the particular periods at which we obtain, lose, and regain our various teeth; for I presume there is an established law of nature with regard to all those processes.

DR. A.

When about seven months old, a child gets the two first lower front or incisor teeth; and in a few

weeks subsequently, the two corresponding upper ones. After a lapse of a few weeks more, the lateral incisors appear, sometimes the lower first, and sometimes the upper. Within the first year, a child therefore gets eight teeth, four below, and four above. At the end of the first year, or beginning of the second, the first grinder appears on each side above and below; and not till some time afterwards do the canine teeth show themselves, though they are next to the incisors, and might be expected to follow them. About the end of the second year, or beginning of the third, the second grinder on each side, above and below, emerge from the gum, and this completes the 20 first or deciduous teeth which we possess.

About the age of six or seven, the two lower incisors are shed; and then follow, after some time, the two upper, whose places are supplied by permanent teeth, which soon appear above the gum. The lateral incisors are next displaced, which are renewed in a similar way: then the temporary molares, and last of all the canine, about the age of eight or nine, which are supplied at irregular periods afterwards. But in the mean time, the first permanent grinder has shown itself about the seventh year; and in the renewal of the deciduous teeth, the permanent follow the shapes and designation of those which they succeed, with the exception of the two temporary molares, which have

the two permanent bicuspid or two pointed substituted for them; the last of which, however, does not appear till the 10th or 11th year. By that time, or a little subsequently, therefore, the child has a renewal of all the 20 deciduous teeth; and to these have been added, as I have already mentioned, about the seventh year, the first permanent grinder. The second permanent grinder does not follow till about the 12th or 14th year, and the wisdom teeth complete the number, about the 20th or 21st year, and after the jaw has acquired its full magnitude. It must be observed, however, that there are many varieties in the particular order and period at which teeth either shed themselves originally, or are shed or renewed.

CHARLES.

It appears, therefore, that when that part of the jaw which contains the temporary teeth becomes too large for them, other teeth are supplied of a larger description, which are permanent; that the back part of the jaw, which originally had no teeth in it, becomes lengthened with the increase of years; and that in order to supply the vacant space which such increase of length would occasion, new teeth are afforded in proportion to the increased length which the jaw obtains; and that finally the space is filled up by the tooth of wisdom, when the full length has been obtained.

DR. A.

This is precisely the case; and we shall find, when I mention to you the mode in which the formation of the teeth takes place, that this plan is admirably adapted to the object in view. The carnivorous and omnivorous animals have teeth of a similar kind; but it is to be observed, that many of the carnivorous animals are beasts of prey, and that their teeth are part of their natural weapons of attack. The tusks or canine teeth, are, in such animals, and indeed in some others, as the hog, very formidable instruments of offence; and, when conjoined with the sharpness and strength of the claws, they render many animals of the cat kind, as lions, tigers, leopards, &c., very terrific foes.

SOPHIA.

The graminivorous animals seem to have the peculiarity of teeth which you mention as belonging to them, in order the better to fit them for using that kind of food which is intended for them, and which requires a great deal of grinding; but their front teeth, I should imagine, like ours, are solely intended for cutting, and, therefore, do not require any particular extra provision.

DR. A.

The front teeth, or incisors, have not usually

... front teeth ... the grass, have them shar... these teeth covers their outsi... neither cattle nor sheep have ... jaw. In horses, where both th... molares are employed as gri... distributed through the body ... descriptions of teeth, in the w... scribed as belonging to gramin...

CHARLES.

One observes, in looking in... that the division into two subs... seen; and, I suppose, that a h... called the mark of mouth when ... of attrition has rubbed down a ... substance, so as to take off the ... vity in the front teeth.

DR. A.

This is the case, for the ena... teeth descends but a short way i... the tooth; and horse-dealers some... give an ...

CHARLES.

I wish that I knew a little more about the marks of mouth in a horse; and, perhaps, you can give me some information on this subject, which I hope the girls will excuse.

DR. A.

I think I am enough of a jockey to tell you all that is principally worth knowing on the subject. It is not alone by the marks on the teeth of horses that their ages are judged of, but by the number and description of the teeth which they possess; and which, in cattle and sheep, likewise afford to graziers the means of determining the ages of those animals. The horse has forty teeth, viz. 12 front teeth, six above, and six below, which are called incisors or nippers; twenty form molares or grinders, six on each side, above and below; to which are to be added, four canine teeth or tushes, one above and one below on each side, which are generally wanting in the mare. From 2½ years old to three, a horse sheds the two middle teeth of the lower jaw, and the corresponding teeth of the upper. From 3½ years old to four, he sheds the two next in both jaws. From 4½ to five, he sheds the two outermost front teeth in each jaw; and at the same time the canine teeth, or tushes, make their appearance. From five years old to seven, the age is judged of by the appear-

ance of the cavity in the front teeth, as you have already noticed. The two middle lower teeth, which are lost first, and are, therefore, removed earliest, have this cavity soonest worn down; and at five years old, the black marks in them have nearly disappeared. At six the same has happened to the two next teeth; and from seven to eight years old, the marks in the two corner teeth are worn down, so that all power of discriminating the age of a horse, as far as the lower front teeth are concerned, is lost. At the same time the tushes alter their shape, and become round, or convex next to the tongue, instead of being concave. After the age of eight, we look to the upper teeth, and to some other circumstances, for judging of the age of horses; for the upper teeth are not worn down so soon as the lower. At eight, the cavities of the two middle upper teeth disappear; at 10, those of the two next; and at 12, those of the corner, or outermost. Aged horses lose the transverse ridges which are so prominent on the roof of the mouth of the young, and which gradually become flatter and more level, as they advance in life. The eyes likewise become more sunken, the eyelids lean and wrinkled, and the cavity above the eye more hollow. Grey hairs shoot out upon the forehead, and lower part of the mouth; the lips become lean and shriveled; the lower lip hangs much below the upper; and the ears drop laterally.

CHARLES.

Are there no means of discovering the deception which dealers practise on the teeth of horses, to make them appear within mark of mouth?

DR. A.

A little observation will enable a person to detect the fraud; for in a young horse the front teeth meet perpendicularly; while, as he grows older, the teeth take a more horizontal direction; the upper teeth projecting over the lower ones, and the upper corner tooth forming a curve over the lower corner tooth. Furrows likewise appear on their front surface, and their colour becomes yellow and opake.—As a horse at five years old is more saleable than one at four, attempts are sometimes made to give a horse of four, the appearance of being five, by drawing the outer front teeth in each jaw, in order to protrude the new teeth prematurely. It may, however, always be known that a horse has not attained his fifth year, if the corner teeth, above and below, are not complete in their size and appearance, and the marks of the middle teeth do not begin to be obliterated.

CHARLES.

I suppose the direction of the enamel in the teeth of graminivorous animals, or the numbers of layers, is not material?

DR. A.

It does not appear to be so; but yet there is a great similarity in the distribution of this substance, in the same genera of animals, as indicated by a similar waved appearance which it exhibits on a horizontal section. — There is a very curious difference in the disposition of the enamel in the African and Asiatic elephant, which is worth your notice and recollection. In the African, it is always in the form of transverse lozenges, which touch each other in the middle of the tooth; in the Asiatic, in the form of transverse flattened ovals; and this difference is so constant, that you may always know, by a slight inspection, whether the tooth has belonged to the one or the other of these species.

SOPHIA.

But is not ivory the product of elephants' teeth? The substance is uniform, and does not present the differences which you mention.

DR. A.

The ivory is furnished by the tusks, and not the teeth; and these former are planted in the upper jaw, and are of the largest size in male elephants.

CHARLES.

I recollect once seeing a ball in the tusk of an elephant. It obtained its position, I suppose,

during the growth of the tusk, and while its ossific matter was not sufficiently consolidated.

DR. A.

Certainly, for a ball might afterwards break, or otherwise injure, but could not enter into a firm tusk.

HARRIET.

One would suppose, from the appearance of teeth, that they were an insensible mass; and yet they must be plentifully supplied with nerves, as there is so much suffering in them.

DR. A.

They are destined to be terrible plagues to mankind; for they are obtained with suffering in infancy, and are frequently productive of great distress in after life; and though they exhibit no particular sensibility in ordinary circumstances, yet, when the substance of the tooth becomes decayed, and in particular when the nerve becomes by this means exposed to the air, intolerable pain is produced.

HARRIET.

I have often wished that the teeth were totally insensible; and, indeed, I do not exactly see why so extreme a sensibility should be given to parts, which are merely intended to act as solid bodies.

DR. A.

You must recollect what I remarked relative to the structure and growth of bones, in order to be convinced that an organisation of nerve and blood-vessel is necessary for their production, as well as for preserving them in health. The same is the case with the teeth; but the vitality of the latter, if we may so term it, does not seem to be so active as that of ordinary bone, which possesses, as I have already explained to you, a principle of reparation of which the teeth are destitute. The formation of the teeth is an example of an interesting process in the animal economy, very analogous to the formation of bone. Before the jaw is thoroughly ossified, several little bags, or membranes, are discoverable in it, which adhere firmly to the gum, and are supplied liberally with blood-vessels. Into these little bags, the blood-vessels throw a portion of pulp, or jelly, which is intended to form the future tooth. At first there are no sockets, but the edge of the jaw shoots out bony fibres, which form them. Bony matter, in time, is thrown out on different parts of this pulp, generally answering to the number of prominences, and forming either one, or several small elastic shells, which gradually unite, so as to produce one solid mass. An elongation of pulp forms the material for the formation of the roots; and in proportion as this deposition, and its ossifi-

cation takes place, the body of the tooth rises in the socket, till, by pressure on the gum, it wastes it, and the tooth begins to appear in the mouth.

SOPHIA.

So that, in fact, it is by the growth of the part beneath that the tooth is forced up; but does the membrane rise up with it, for I never heard of a tooth being covered with a membrane?

DR. A.

As soon as the body of the tooth is formed, there is no further occasion for a secretion of bony matter from the upper part of the membrane; for you will observe, that in the lower part, or the roots of the tooth, the membrane is carrying on its secreting operation, long after it has ceased to do so above. As soon, therefore, as the ossific process is completed in the body of the tooth, the membrane changes the nature of its secretion, and covers all that portion which is intended to be exposed, with a soft and moist deposit, which gradually hardens, and forms the firm and indestructable substance called the enamel. The investing membrane having thus completed its function, is wasted, and separates; but it remains permanently attached to the roots of the tooth, and when inflamed, gives the sensation of the tooth being elongated.

HARRIET.

Our first teeth last us only a certain time; they seem to decay away at their roots; and nature appears to have anticipated this, by forming a second set for the purpose of supplying them.

DR. A.

You will find that this decay is only a disappearance; and that the two processes of forming the new tooth, and removing the old one, go on at the same time.

SOPHIA.

I cannot understand how this can be the case.

DR. A.

When the rudiments of the temporary teeth are pretty far advanced, the upper part of the original membrane sends off a new sac, or bag, to the place of deposit for the pulp of the new tooth. As the temporary teeth rise, the membrane which joins the two sets is elongated, and in time the new one gets a socket of its own. The process of deposition of pulp; its ossification in various parts, answering to the future prominences; and the secretion of enamel, go on, in succession, in order to prepare the second set for taking a permanent place as successors to the first. The continual accession made to the roots forces up the body of the tooth, which, pressing against the socket, and

then against the roots of the first set, produces an absorption or disappearance of them; till, in time, the old tooth, being held only by the gum, drops out with a very little force. In the sketch which I now show you, A represents the sac containing the milk, or temporary tooth; B the sac of the permanent tooth attached to the sac of the milk tooth; C an incisor tooth above the gum, with its root unabsorbed, and a vacant space at its side, from which another incisor has fallen; D a permanent tooth, rising up to supply the place of the temporary one which has been lost; E the spongy part of the jaw.

SOPHIA.

But in what way can mere pressure produce the disappearance or absorption of the roots of the teeth?

DR. A.

This is a very usual effect of pressure, and by no means a solitary example in the animal economy, as I mentioned when we were on the subject of the bones. Tumours, for instance, which grow slowly, and particularly that species which is called aneurism, will, by continued and increasing pressure, often produce a gradual disappearance of contiguous bones; such, for example, as the breast bone, when the aneurism happens to lie in the chest, and immediately under it.

HARRIET.

But we sometimes observe that people have very irregular teeth, and that the new ones have not grown exactly below the others: would this process of absorption be interrupted in such a case, and should we find the old ones with roots, instead of being half eaten away, as they appear to be when they quit the gum?

DR. A.

Under such circumstances it is often prudent to extract the old tooth, in order to make room for the new one; and then the root is frequently found either whole, or partially only absorbed; because the necessary pressure against it had either been wholly, or in part wanting.

SOPHIA.

This is really a very beautiful provision of nature; but it is a great pity that there is not a greater provision of those useful little bags of pulp, by means of which the teeth might be restored after they are lost.

DR. A.

Perhaps you might likewise wish, that nature had dispensed to mankind a longer protraction of existence, and thus altered her original designs. It does happen, however, that in some very rare instances, old people have unexpectedly got new teeth in advanced life, which must have arisen from an additional sac having originally existed, or been formed under peculiar circumstances.

In another sketch, you will see the appearance of one side of the lower jaw, when all the five temporary teeth have arisen above the gum; and below these teeth you may observe the permanent ones, which are preparing to supply their places. A permanent molaris is far advanced, and is ready to take its position among the other teeth; and the other molares, as I have already stated, appear in succession, up to the wisdom-tooth, in proportion as the jaw becomes sufficiently elongated to receive them.

HARRIET.

You mentioned the shedding of teeth in horses, cattle, and sheep; and I suppose the same circumstance takes place in other animals.

DR. A.

In most animals a part of the teeth is shed, and for the same reason as in man; namely, that the original ones, which are adapted to a small jaw, will not do for a large one; and as the teeth cannot grow, after they are fully formed, a new set became necessary for the enlarged space which they were to fill.

CHARLES.

The circumstances which you describe, as attaching to the formation of the teeth in man, apply of course to other animals; but I am curious to know how the enamel is diffused through the body of the tooth in graminivorous animals.

DR. A.

Animals of this kind have, like the carnivorous and omnivorous, a membrane, or sac, in which the pulpy matter is lodged; but this membrane, instead of merely surrounding the pulp, doubles down into it, in several places, and thus divides it into several portions, or compartments. When ossification is completed in each of those portions, the membrane assumes its new office of secreting enamel, which it deposits against the perpendicular masses of bone. A very little consideration will show you, that when once the upper surface is worn off, an appearance of alternate layers of bone and enamel will be produced. But, in this case, it will be seen, that a small vacuity is apt to be left between each pillar of ossified substance. When this occurs, it is either filled up with portions of food, as is frequently the case in the ox or sheep, or with sand or clay; or the membrane itself, or an external layer of it, secretes a sort of substance, intermediate between bone and enamel, which supplies the whole of the interstice. This has been called the *petrous crust*, and occurs in almost all the graminivorous class of quadrupeds. It does not exist in the incisors of the horse, and hence the appearance of the cavity, which, till it is worn away, affords the means of determining his age.

SOPHIA.

Then, in fact, we may conceive the enamel to dip down and return in a tooth, very much like the finger of a glove over the fingers.

DR. A.

Very much so; and if two or three fingers of a hand, with a glove on, are placed together, they may represent the grinding teeth, before they are worn by mastication. If you cut off the ends of the glove, and leave the fingers exposed, the fingers may then, in a rough way, designate the bony part of the tooth, and the glove between them, the enamel descending into its substance. The enamel between the different processes of the tooth will be double, just as the glove is, between two particular fingers; and between the doublings, either the petrous crust, which I have mentioned, or portions of extraneous matter, may obviously be admitted. —There is a very curious circumstance which I must notice to you relative to the teeth of the elephant. In this animal, the enamel, as I have already observed to you, descends into the body of the tooth; but the grinders are so soon destroyed by attrition, as to require a means of renewal which does not attach to the other descriptions of graminivorous teeth. The jaws of the elephant are furnished with one large mass of tooth, hard in the front and exposed part, and soft and pulpy

behind. As soon as mastication has rubbed away the front portion, the hinder is pushed forward by the formation of pulp, and conversion of it into ossific matter, at the same time that the fangs of the part whose body is rubbed away are absorbed, in order to make way for the protrusion of the part behind. The elephant's teeth are, therefore, in a continual state of destruction and renewal.

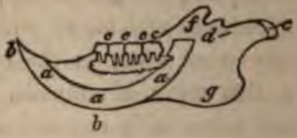
CHARLES.

How very admirable are the resources of nature for the protection and comfort of animal life. I could not have imagined, till you favoured us with these details, that teeth could afford so much opportunity for the exhibition of beautiful design and admirable adaptation; but is such a process of renewal frequent among animals?

DR. A.

Not very frequent. A similar structure, however, has been discovered in the Ethiopian hog; but in the shark, whose teeth are spear-shaped and very sharp, notched at the edges, and covered with enamel, several ranges of them are formed, and continually forming in the jaw, to supply such as are broken or torn away. The same is the case in a species of skate, which has teeth of a similar kind, and is apt to have them injured, by breaking the shells of lobsters, crabs, &c. which form its chief food.

in gnawing; and you are right in supposing, that there is a particular provision, by which the surface, necessarily worn away in the operation, is supplied. In this tribe of animals, the incisor teeth have their fronts only covered with enamel, by which means they are sharp, and are adapted for cutting through solid wood; for the other part of the tooth, consisting of the common softer material, is worn away by attrition, and thus leaves the enamel of the front projecting and sharp, but necessarily in a continual state of destruction, by the use to which it is constantly appropriated. The mode which nature adopts for the purpose of supplying this daily waste, resembles, in some degree, that which is employed in the grinders of the elephant; for the incisors, instead of being shed, as in other animals, have the origin of their roots at a considerable distance in the jaw; and these roots being supplied by the constant augmentation and consolidation of pulp, the body of the tooth is carried forward, according as the friction has worn it down. You will be able to form an idea of this curious structure, from the little sketch which I now show you of the incisor in the squirrel; in which, *a a a* represents the bony part of the incisor, extending very far back to the root of the process of the jaw, and covered with enamel at *b b*; while *c c c c* are the grinders, *d* the cavity of the jaw for the admission of vessels, and *g* the angle of the jaw.



CHARLES.

Is any thing known concerning the chemical nature of the hard enamel which performs so important a part in the animal economy?

DR. A.

The solid part of bones, teeth, and enamel, consists principally of phosphate of lime, or bone-earth, united with a small portion of carbonate of lime, or chalk. This solid matter is, as I observed when we were on the subject of the bones*, capable of being removed by the action of acids; and then, in the case of bone and teeth, it leaves a considerable portion of animal matter, in which the bony substance was included, untouched. By the same process, however, the whole, or very nearly the whole of the substance of the enamel is entirely dissolved. It is, therefore, to the almost entire absence of animal matter, that the enamel owes its peculiar character; and it seems to be thrown out on the substance of the tooth, in a state nearly fit for assuming the crystallised form in which it ap-

* Vol. I. p. 119.

pears, instead of being the last of a succession of secretions, as is the case with bone. This, I stated to you *, was preceded by jelly and cartilage; but though these substances are absorbed, in succession, in the formation of bone, to make way for the hard material which is to give the bone or tooth solidity, yet this is not wholly the case; for you may recollect that boiling, as I mentioned to you, will dislodge a considerable portion of animal matter, in the form of jelly, and leave the solid, or earthy part, unaffected. This solid material is, to all appearance, destitute of further animal matter; but by long continued boiling under high temperature, as by the use of Papin's digester, (which is a vessel so contrived, as to admit the temperature to be raised much above the boiling point,) still more is to be obtained, which is found to be of a cartilaginous nature, and is what remains of the second constituent of bones, to form, with the cellular membrane, a frame-work, and permanent component part of their substances, which is so firmly adherent, as to have sometimes remained unaltered for centuries.

CHARLES.

Then, in fact, as bones are in a continual state of change, by absorption of old parts, and deposition of new ones, there must be a continual se-

* Vol. I. p. 116.

cretion of both jelly, cartilage, and bone, in order to keep up the relative proportions of each.

DR. A.

This must, of course, be the case, and therefore Harriet's idea, of the probable intermixture of those three substances in the composition of bone, was to a certain degree well founded.

HARRIET.

But as the teeth of man, and most other animals, when once formed, are destitute of the power of reparation, is there any reason for supposing, that the same process of renewal is going on in them, as in bone?

DR. A.

There has been a good deal of difference of opinion among writers of the best authority on the subject of the teeth, as to their precise nature; some regarding them merely as inorganic bodies, owing their sensibility only to the remains of nerves in the cavity designated in the section of the tooth which I showed you; others as possessing circulating vessels, and the ordinary accompaniments of common bone. The evidence in favour of their vitality is, however, very strong. They adhere firmly to neighbouring parts; and will take root again, if put in their places, or into the jaws of other people, as soon as extracted. They can likewise fix themselves, when recent,

in any whimsical place to which they may be attached, as the comb of a cock, if its surface be abraded. Putting aside their sensibility, which, as I have just mentioned, has been referred to the nerves existing in the cavity of the tooth, the fangs of the first set, though completely solidified, are capable of being absorbed by the pressure of those of the second, just after the analogy of absorption in other parts of the body. The circumstance, however, on which most stress has been laid, in order to show that some such process of absorption and renewal as that concerning which you inquire, goes on in the teeth, though with less force than in bone, and with much modification from the decay to which they are subject, is, that the teeth, as well as the bones of animals, are capable of being tinged by madder given to them for some time with their food; and that this colour disappears in a short period after the madder has been discontinued.—I mentioned to you that boiling will withdraw the animal from the bony part of bones; and acids, the bony from the animal. A consideration of the last circumstance, has given rise to the employment of dilute muriatic acid to remove the bony part of bones, and thus to leave a much larger portion of the animal material available, than can be obtained by almost any process of boiling. It has hence been ingeniously suggested, that if such cities as might at any time be in

danger of a blockade, were to have depositories of the bones of animals used as food established in them, there might thus be an almost inexhaustible store of nutriment provided for an exigency. A machine for bruising the bones, and a sufficient quantity of acid to separate the earthy part of them, are all that would be necessary for carrying on this process; while careful washing would readily separate the acid and saline particles, so as to prepare the animal matter for nourishment.—Before I take leave of this subject, I may mention, as connected with the incidental observations on the nature of bone, which I have now made, that the shells with which several marine and fresh water, as well as land animals are covered, consist principally of carbonate of lime, united either by jelly or cartilage; and that egg-shells, and the shells of the crustaceous animals, as lobsters, crabs, shrimps, &c. consist of carbonate of lime, united to a little phosphate of lime, and cemented with animal matter.

CONVERSATION XV.

OF DIGESTION.

DR. A.

DURING the action of chewing, the food is mixed with the *saliva* or *spittle*, which, as I have already mentioned *, is a secretion from three sets of glands, the parotid, submaxillary, and sublingual, placed in such a manner, that their ducts open into the mouth, and continually pour this fluid into it, but more particularly during mastication. The food is then carried backwards, and by the curious action of various muscles is thrown into the *pharynx*, which is a sort of pouch, or expansion in the back part of the mouth, from which it immediately descends, partly by its own weight, and partly by the action of muscles belonging to the pharnyx, into the *æsophagus or gullet*, at the extremity of which is the *stomach*, into which the food is deposited.

* Vol. I. p. 256.

CHARLES.

The gullet, then, I suppose, lies immediately behind the windpipe; but as we breathe through the same opening by which the food passes, there must be some method adopted, by which the food is prevented from ordinarily getting into the windpipe, which it now and then does, and producing great inconvenience.

DR. A.

The gullet and the windpipe lie parallel to each other for some distance. At the upper part of the gullet is the pharynx, which I have already mentioned; and at the upper part of the windpipe is the larynx, which is the projecting body that you may feel, just below the chin, at the front of the neck. It is hollow, and is connected with the windpipe, so as to admit air to pass through it, into the lungs. During the act of swallowing, the tongue is drawn back, and the larynx, upwards and forwards; so that the opening into it, through which the air passes, is protected by the root of the tongue, and closed by a sort of valve or cover, called the *epiglottis*, which I shall have occasion to notice in speaking of respiration. To these circumstances, however, a certain action of muscles belonging to the larynx is added, by which the opening into it is closed; for it has been found that when the epiglottis has been removed, or has been lost

by disease, there is still a means existing, of closing the aperture into the windpipe during swallowing, and of therefore preventing the food from passing that way. It thus appears, that respiration is for an instant interrupted in swallowing, to allow the food to pass onward, without injury to the delicate and sensible organs concerned in carrying it on. But it is to be observed, likewise, that there is an opening from the nostrils into the pharynx, through which it is equally necessary that the food should be prevented passing, as down the windpipe. The soft palate of the mouth is carried backwards in the act of swallowing, and sufficient tension given to it by the action of the muscles which it possesses, so as to force on the food in its proper course; while the muscles of the larynx itself contract on the food admitted into it, and propel it onwards to the gullet.

CHARLES.

Does the food, then, when it is received into the gullet, pass on to the stomach by its mere weight; or has that tube any power in passing it forward? I should think there must be some muscular structure connected with it, for I have seen tumblers drink when they were standing on their heads; and we know that various animals feed and swallow, when their heads are close to the ground.

DR. A.

You are quite right. The tube is lined with a white smooth membrane, which is covered with a secretion of mucus, produced from some small glands below it, to keep it moist; but it consists chiefly of fleshy or muscular fibres, some of which are longitudinal, and some transverse, by means of which the gullet contracts upon any substance admitted into it, and drops it into the stomach. There is likewise, at the root of the tongue, a bone, of the figure of the letter υ, and hence called the hyoid, which serves to keep the tongue and palate expanded, and always ready, therefore, for the reception of food.

HARRIET.

You mention that the secretion of saliva is considerably increased during the act of chewing; but it seems also to be augmented by the mere appearance, or even thoughts of food, when a person is hungry.

DR. A.

There is certainly such a sympathy as that which you mention; and it appears, from a curious example which occurred some years since in Edinburgh, of a person who attempted self-destruction, by cutting across both the larynx and gullet, that during the cure, (for the person recovered after so

grievous an injury,) when nourishment was thrown into the stomach through the wound, there was always, by a sort of sympathy with the stomach, a considerable secretion of saliva from the mouth, to the extent of even from five or six, to eight ounces or more each meal.

HARRIET.

Then the quantity secreted in ordinary circumstances, is far more than one can have any idea of from one's own personal observation on the subject.

DR. A.

It has been supposed, that not less than a pound of saliva is ordinarily secreted during the 24 hours; and you may readily imagine this, when you consider the constant necessity which there is, to swallow the saliva which the salivary glands are continually pouring out. Any irritating substance, as tobacco, will increase the quantity exceedingly; and it is likewise capable of great augmentation, not only by medicine, but in various states of disease.

CHARLES.

I suppose the tartar which forms upon the teeth, when they are neglected, is to be attributed to the saliva in some way or other.

DR. A.

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DR. A.

Certainly; and in this way it assists in the pre-
paration of the food for the action of the stomach,
which is the organ that I must now mention to
you.

DR. A.

Saliva consists of more than 92 parts in the 100 of water; and as the remaining ingredients possess mucus, and some peculiar animal, with a small portion of saline matter, the mucus hardens when it is suffered to remain on the teeth, and in time forms what is called *tartar*, which is principally constituted of phosphate of lime, the production of which substance from mucus is rather obscure. A late examination of the white coating which often forms on the tongue, particularly of persons who are subject to indigestion, has however discovered, that it contains a considerable proportion of phosphate of lime; and is hence a probable source of the tartar of the teeth.—The saliva mixes difficultly with water, and, therefore, cannot be effectually removed from the teeth, but by brushing.

CHARLES.

The principal use of the saliva is, therefore, that of affording moisture sufficient to enable mastication to be performed adequately?

DR. A.

Certainly; and in this way it assists in the preparation of the food for the action of the stomach, which is the organ that I must now mention to you.

The STOMACH in man is a membranous bag, not very unlike the shape of the bag-pipe, lying across the body, and having two openings; the upper, towards the left side, by which it receives food from the gullet, called the cardia, from its supposed sympathy with the heart; and the lower, on the right side, called the pylorus, janitor, or porter, by which the food passes on to the intestines. Its inner surface consists of a soft, and rather pulpy membrane, called the mucous, or villous coat, which is carried through the whole alimentary canal; its middle, or body, consists of a muscular expansion, by which this organ is capable of emptying its contents; and its outer is a membranous covering, common to the stomach, intestines, and all the other organs contained in the cavity of the abdomen, and to which I shall afterwards have occasion to advert. The inner coat is united by cellular membrane to the muscular; but it does not contract with the contractions of the latter, and therefore frequently exhibits the appearance of folds. At the pylorus is a contraction which prevents the too ready passage of the food downwards. You will be able to form a correct idea of the shape of the stomach from the sketch which I now show you, in which the upper, or cardiac orifice, into which the œsophagus is inserted, is towards the right, while the pyloric is on the left side.

SOPHIA.

But I thought the stomach had been a very strong organ, capable of bruising and squeezing out the nourishment from the food which it receives into it. In what way, then, does it act in digesting our food?

DR. A.

Between its coats are various small glands, which are plentifully supplied with blood-vessels and nerves, and which secrete, and pour into the stomach, a fluid called *gastric juice*, which dissolves the substances taken into the stomach, converts them into an uniform, greyish, pulpy mass, called *chyme*, and thus fits them for becoming nourishment.

SOPHIA.

Is this, then, totally independent of any pressure which is exercised by its coats?

DR. A.

Entirely so; for it has been found that if portions of food were placed in silver balls, and these swallowed, such portions would be dissolved, notwithstanding they were placed out of the reach of pressure. Various interesting experiments were made, many years ago, on a German, who was in the habit of swallowing stones to gratify curiosity, by which this fact was satisfactorily made out.— When the food has undergone, to a sufficient extent, the change which it is meant to suffer in the stomach, it passes through the pylorus, or lower orifice, into the intestines. But care is taken that it does not quit the stomach too rapidly for the necessary changes to be effected in it. This is provided for by a sort of contraction at the pylorus, and by the food lying below it, so as to require a considerable exertion of muscular power to carry it up to, and then through this opening. When the food has passed into the intestine, it receives the *bile*, which is the bitter yellow secretion from the liver; and the *pancreatic juice*, which is the secretion of the pancreas, or sweet-bread. By the mixture of those substances, and of other secretions from the sides of the intestines themselves; and by the changes which are effected spontane-

ously, the food is so far altered in its nature as to be capable of affording *chyle*, which is a fluid, like milk, that is taken up by small vessels, called *lacteals*, from a large part of the surface of the intestines. These lacteals, uniting together, convey their contents into one of the large blood-vessels of the body, and thus supply the means of nourishment to the system. That part of the food which cannot afford further nourishment, is carried off as excrementitious matter.

HARRIET.

How very simple this view of an important process is. But it seems to me very extraordinary, that, whatever the description of food may be, there should always be chyle formed from it. Is chyle always of the same nature?

DR. A.

It is quite the same in all its more important properties, though there are some slight chemical differences; but the peculiar changes which are necessary for its production are very little known. Nature, however, has imparted to all animals certain powers of assimilation, by means of which, and the various decompositions and new combinations to which the food is subject, first, chyme, then chyle, and finally blood, are formed, of whatever aliment the animal may have been nourished.

SOPHIA.

Has this absorption of the chyle been seen in

animals which may have died during the process of digestion?

DR. A.

It is easily discoverable in any animal within five or six hours after eating; and I have seen it myself, very distinctly, in the body of a malefactor, which was given up by the law to surgeons for dissection. Through the whole course of the intestines there were small white lines perceptible, which were found to be the lacteals; and on opening any of them, a portion of milky fluid was capable of being collected.

CHARLES.

I have heard of fermentation going on in the stomach, and perhaps this may be evinced by the sense of distention which is sometimes felt, and by the occasional disposition to eructate.

DR. A.

These are both diseased feelings, for a perfectly healthy stomach has none of them. The discovery of the solvent powers which the gastric juice possesses, evinces that the process of fermentation is quite unnecessary for the conversion of the food into chyme, and afterwards into chyle. The frequent derangements of the stomach and alimentary canal, the overloading of the stomach, or the employment of food difficult of digestion, often prevent the agency of the gastric juice from

taking effect at the proper period. Detention of food in the stomach allows, in such cases, of the occurrence of fermentation, which some are disposed to consider as in the regular course of things.

CHARLES.

It is said that some animals, as birds, take in portions of gravel and stone, as if the digestion of the food were assisted by some sort of friction; and yet you say that digestion goes on independently of the pressure exercised on the food.

DR. A.

I have hitherto spoken only of the human stomach, which is of a membranous nature, and therefore totally unfit to press on the food which it may contain. All carnivorous animals have stomachs of the same kind; and I may remark of them, that animal, or mixed food, is more readily assimilated, that is, more readily converted into chyle, than any other description; and the digestive organs in such animals are of the more simple kind. Many birds not only take in portions of gravel to assist their digestion, but as they have not teeth, and can divide their food in but a very imperfect manner with their bills or beaks, it is necessary that a more minute division should take place, in order to prepare it for the process of digestion. The *gizzard* of birds is therefore given them for the purpose; and it is

formed of two very thick and strong muscles, or rather one muscle with two bodies, and called, therefore, digastric, calculated to press any substance very strongly between the two parts of which it consists. But as the gizzard could not perform the whole of the duty at once, there is a bag, or enlargement of the gullet given to many birds, called the crop, which is situated in the front of the chest, at some distance from the gizzard. In this, the hard and dry food is macerated; it is then let into the gizzard, where it is bruised and divided; is mixed with the gastric juice, which is secreted by glands near the entrance of the gizzard; and thus the changes are produced which fit it for nourishment.

CHARLES.

It therefore appears that the stomach of such birds consists of two essential parts; the one, which triturates and divides, acting the part of teeth; the other, which secretes the fluid necessary for the solution and preparation of the food for nourishment.

DR. A.

Certainly; and you will understand this the better, from a sketch which I shall show you, of the exterior and interior of the stomach, or gizzard, of a wild swan. In the view of the exterior, *a* represents a number of the glands which secrete the gastric juice, with their external extremities

exposed by a portion of the muscular coat being removed; *b b* are the fleshy fibres of the digastric muscle, which forms the great mass of the gizzard; *c* is the tendon which connects them with each other; and *d* is the commencement of the intestine, which carries the food downwards.

In the sketch of the interior of the gizzard of the same animal, you are to suppose it opened from above downwards, in the direction of the line

on the right, to the lower corner on the left, and the parts thrown back. Here *a* represents the orifice of the gastric glands in the interior of the stomach, answering to the glands *a* seen from without in the former sketch; *b b*, as in the former sketch, are the fleshy fibres of the digastric muscle divided; *c* is the tendon divided; *d* is the opening into the intestine; *e* designates the mucous glands around the termination of the gullet; and *f f* the cuticular, or horny covering of the gizzard, which is the part that triturates the food.

CHARLES.

At the time of trituration, the gastric juice is of course dropped on the food from the glands placed above.

DR. A.

This is the case, though the gastric glands vary in their position, being in some birds much lower down than in others; but there is a provision for the food not being too speedily carried onwards, by the intestine being joined to the gizzard very high up, so as by this means to allow sufficient time for completing the digestive process. The crop, in such birds as have one, is principally to be viewed as a repository from which the food is first softened, and then transmitted to the gizzard. But in all birds of the dove kind, and there is some reason to suppose this to be the case in parrots, mackaws, and cockatoos, the crop, both in the male and female, is endowed with a power of secreting a fluid, which coagulates into a whitish curd, and is employed to feed the young for two or three days after hatching. It is then found to be mixed with some of the common food; and as the pigeon grows older, the proportion of common food is increased; so that by the time it is eight or nine days old, when it is able to digest the common food, the secretion of the curd in the old bird ceases.

SOPHIA.

This is a very curious provision; and I suppose the kind parents have the power of sending up the curd without the mixture of common food, and of apportioning the respective quantities according to the age of the young.

DR. A.

This must either be the case, or they must accommodate their periods of taking food to the mixture which is required of it with the curd. But in either case, there is a wonderful display of instinctive knowledge.

CHARLES.

I have heard of the stomachs of ostriches being able to digest iron, and other hard substances: is there any truth in such stories?

DR. A.

The powerful gizzards of ostriches soon alter the shape of a strong metallic body, but can do no more. Balls of glass are, however, readily broken and powdered, by the action of the gizzard even of the common barn-door fowl.

SOPHIA.

I should have thought that the introduction of such substances risked a material injury to the animal.

DR. A.

So far from it, that needles, and even lancets, have been broken to pieces by the action of the gizzard, and no disadvantage sustained; for the hard tendon with which it is covered resists the strongest impressions.

SOPHIA.

The gizzards of fowls which one sees at table are hard and firm; but I should scarcely have thought them equal to a resistance so great as what you mention.

DR. A.

Because the tendinous part has been removed in the trussing, and the fleshy digastric muscle joined by the tendon on one side left; the other tendon being divided, so as to allow the muscle to be separated into its two divisions, and thrown back. In some of the crustaceous animals, as the lobster and crab, the division of the food is accomplished by means of teeth placed in the stomach, and covered with the same hard materials as the external coat. These teeth are of the molaris or grinding shape, and are one on each side. Immediately beyond them, is a single projecting tooth, which answers 'the purpose of preventing the food from passing on, till it is sufficiently divided. The stomach of these animals is also lined with a hard substance similar

to the external coat, so as that it is never collapsed; and it is a curious circumstance, that this coat, as well as the hard covering of the teeth, are parted with when these animals cast their shells. The tooth-like processes at the entrance of the mouth, which are sometimes represented as the teeth, are nothing more than a kind of pincers, to grasp the food, and convey it into the mouth.

HARRIET.

How extraordinary it is, that these animals should be able to digest their own stomachs and teeth.

DR. A.

This must be pretty nearly the fact; and I imagine that it is a provision against the injuries which these organs must occasionally meet with. In some of the worm tribe, teeth are likewise met with in the stomach; and such is also the case with various insects, particularly the Cape grasshopper, and mole cricket, of which last, there is a very accurate description, with plates, published by Dr. Kidd of Oxford, in the Philosophical Transactions for 1824.

CHARLES.

What special provisions nature seems to have taken for the proper division of the food. But is the peculiar structure which you mention in birds

common to all of them? for I should have thought such an apparatus unnecessary in those which live upon flesh.

DR. A.

Birds of prey, such as eagles and hawks, and those also which are principally carnivorous, as rooks, have stomachs that are nearly membranous. So have birds that live upon fish, which occupy a very large space, and are swallowed whole. These last, and also many of the birds of prey, have crops, or very wide gullets, which act either as repositories of food, or admit of a part of it being lodged in them, till the further part, which has reached the stomach, is digested; and then the remainder is taken in, and subjected to the same process. A friend of mine found a large rat in the crop of an eagle which was accidentally strangled by its chain; and another, partly in its stomach, and half digested, and partly in the gullet, contiguous to the stomach. A great power of distension exists in the serpent tribe, which are capable of swallowing large animals, the whole of which the stomach cannot receive at once. The boa constrictor, before it swallows an animal, prepares it for being taken down, by compressing it to as small a bulk as possible. There is, however, this very singular circumstance attending the stomachs of birds accustomed to live on animal food, that if, from the want of it, they are obliged to subsist on

grain, the digastric muscle forming the gizzard, which is hardly perceptible in them, becomes so large, that it can scarcely be recognized as belonging to the stomach of a bird of prey. This is strikingly exemplified by a preparation which I have seen in the Hunterian Collection, of the stomach of a sea-gull, which had been kept by Mr. Hunter for twelve months on grain, and acquired a very unnatural accession of strength in the gizzard muscles, from this change of food.

HARRIET.

Would the strength of the gizzard, do you suppose, be diminished, as well as increased by a change of food?

DR. A.

I have no doubt that this would be the case, if the experiment were tried, which I do not know that it has ever been; but it would appear, that all such birds as have naturally efficient gizzards, have them of various degrees of strength, according to the peculiar food which they are intended to use. Birds which are carnivorous, have various modifications of structure to accommodate the organ to the different descriptions of animal food. Some which take in grubs, and all sorts of insects, with their food, have a cuticular lining in the stomach, of various thickness, as a defence: others, which are in the habit of swallowing

bones, hair, and feathers, as hawks and other birds of prey, always regurgitate them; and so easily are their membranous stomachs irritated, that old books of hawking recommend, as a receipt for making a young hawk *cast* (as this operation is called), the giving three oats in a piece of flesh. When birds live on shell fish, and sea insects, their gizzards are strong, in order to break them, and at the same time to resist injury from their introduction.

CHARLES.

I presume, that as nature has made so great a difference between the stomachs of those birds which live on animal, and those which live on vegetable food, there is likewise a considerable difference between the stomachs of the carnivorous and graminivorous quadrupeds.

DR. A.

You will recollect, that animal food requires less assimilation than vegetable; and nature has, therefore, adopted various modes for facilitating the conversion of the latter into proper nourishment: one of the first means is a longer detention in the stomach; and this is effected, in many animals, by making the entrance of the cardia and pylorus near each other, so as to produce some difficulty in the passage of the food from the body of the stomach, nearly to the part from

which it was projected into it; thus a longer time is allowed for digestion. In the horse and ass, the left half of the stomach is of a different character from the right. It is lined with cuticle continued from the œsophagus, and the food is for some time detained in it; but it is at length gradually transferred to the right, or the digesting side of the stomach, which is covered with a villous coat, and is supplied with glands for the secretion of the gastric juice. The same structure, to a certain degree, exists in the hare and rabbit; but there is a very curious peculiarity in the horse; and that is, that the inside of its stomach is generally found covered with *botts*, a large sort of worm, which fix themselves firmly, by means of two small hooks, to the inner membrane of the stomach, and seem to be productive of but little inconvenience. They are discharged from the horse, go into the chrysalis state, and soon become flies. The eggs are deposited in such situations as to admit an entrance into the interior of the animal.

The most curious apparatus, however, for assisting in the conversion into nourishment of vegetable food, is that which belongs to the cow, the sheep, the deer, camel, and other animals which usually chew their cud.

HARRIET.

What is meant by chewing the cud? One

often sees this in cows and sheep; but I never could exactly understand why they should be so slow and leisurely in chewing at one time, and so rapid at another.

DR. A.

In chewing the cud, the food is brought up again for the purpose of being subjected to a second mastication.

HARRIET.

Do you mean, that, after being actually received into the stomach, it is subsequently disgorged for this second chewing?

DR. A.

It had been received into the first, or preparatory stomach, *the paunch;* for there are four stomachs which are concerned in digestion in these animals. The first stomach receives the food after a very slight mastication. From thence it goes into the second, the *honey-comb*, in small portions; and when it has been further macerated there, it is carried up into the mouth, by a sort of inverted motion of the muscular fibres of the œsophagus and stomach. It is then chewed, and passes into the third stomach, or *many-pies*, from whence it goes into the fourth, or *read*, the proper digesting stomach, where its conversion into chyme is completed.

HARRIET.

This is a very beautiful provision; but how is the food, which, in one case, is received into the first stomach, in another received at once into the third? Has the animal any power of allowing it to go into the one and not the other, at pleasure?

DR. A.

The two first stomachs, which are connected, as I have mentioned, with each other, receive their contents from the gullet, by a groove which is a continuation of it, having full projecting lips. The lower part of this groove leads into the third stomach, and this into the fourth. Now it is by the opening and shutting of this groove, that the operation in question is effected. When it is open, it is clear that whatever comes from above will have a lateral egress. Thus the food passes into the first stomach, because the groove opens immediately into it. But the groove is endowed with a muscular power, by means of which it is capable, at the pleasure of the animal, of being shut at the side, so as to form a tube continuous with the gullet. When this is done, the food swallowed, passes the first and second stomach, and gets immediately into the third.

SOPHIA.

How very curious is this structure; and how singular it is, that the animal should itself be able

to manage the actions necessary for carrying the various stages of digestion into effect.

DR. A.

This is a very admirable instinctive faculty, and it is the more wonderful, because under some circumstances, where the food is not of a nature to require, or to admit of rechewing, it is received at once into the third or even the fourth stomach. For instance, cows in the north of Scotland, and the Hebrides, are occasionally fed on fish, which does not require a second mastication, and is therefore received at once into the third stomach; and calves, which are fed entirely on milk, receive it into the fourth stomach, without even the intervention of the third, because the third has not been expanded by the reception of food into its folds, and therefore allows the milk to pass at once into the fourth; but in both those cases, there is a voluntary action of the muscles of the groove, which converts it at pleasure into a tight tube, suffering nothing to escape laterally.

CHARLES.

The process of opening and shutting the groove leading from the gullet, seems to resemble that of letting corn down the different chambers of a warehouse, through a hollow tube communicating from the top of the house to the bottom. If the tube is opened at any particular apartment, the

contents will be deposited there; but if it is closed, they will be carried to a chamber below.

DR. A.

Not a bad simile, and, as far as I know, an original one too. — The structure which I have mentioned, applies to most of the ruminant animals; but in the camel, there are some modifications, depending on the habits of the animal. The food is received into the first stomach, from which a muscular power raises it into the mouth for re-mastication. The second stomach consists of cells, and is solely appropriated to the reception of water, from which it passes into the third and fourth, which receive the food after being chewed. The third is very small, and the fourth is, as in the ordinary ruminants, that which is the immediate organ of digestion. There is a curious muscular structure in the camel, by means of which the orifices of the cells are closed, and the water preserved from being mixed with the food. It is this peculiar structure, which, in the camel, dromedary, and lama, fit them to live in sandy deserts, where the supplies of water are so very precarious.

CHARLES.

I have heard of the water being taken out of the bodies of dead camels in cases of great drought; and of these animals being occasionally destroyed,

in order to procure the supply of water which is found within them.

DR. A.

This has occasionally been done, as we are informed by travellers, in cases of great distress for water; and a miserable requital it is for the obligations due to the numerous services of these animals.

SOPHIA.

But is the quantity thus capable of being contained very great?

DR. A.

The cells in a camel which was dissected in London some years since, contained about two gallons; but I have no doubt, that they were capable of containing much more when in a state of distension; and I recollect that Bruce mentions, that four gallons were taken out of a camel during one of his journeys in a desert, where there was much distress from the want of water.

The division into a cuticular, and a villous or digesting portion, which I have mentioned as occurring in the horse, and some other animals, seems to be an intermediate state between the stomach of the ruminants and non-ruminants; and it is found that the kangaroo occasionally ruminates when fed upon hard food, and that its stomach is in part cuticular, and has a power of

contracting in folds, so as to have its contents easily brought up by the muscular action of the stomach. It has been supposed that there is an approximation to this structure in the human stomach, by a sort of contraction occurring between the right and left sides; and this, perhaps, derives some support from the occasional occurrence of rumination even in man.

HARRIET.

What, are there instances in the human race of chewing the cud?

DR. A.

A few are mentioned by authors; but the best-authenticated instance is one which came under the notice of Sir Everard Home. It was that of a young man of 19 years of age, idiotic from birth, and blind. He was very ravenous, and they were obliged to restrict him in the quantity of his food; since, if he eat too much, it disordered his bowels. Fluid food did not remain on his stomach, but came up again. He swallowed his dinner, which used to consist of a pound and a half of meat and vegetables, in two minutes; and, in about a quarter of an hour, began to chew the cud. Sir Everard states his having been once present on this occasion, when the morsel was brought up from the stomach into the mouth with apparently a very slight effort. He chewed it three or four times, and swallowed

it; when there was a pause, and other morsels were brought up in succession. This process was continued for half an hour, and he appeared to be more quiet at that time, than any other. But whether the regurgitation of the food was voluntary, or involuntary, could not be ascertained; as the young man was too deficient in understanding, to give any information on the subject.

CHARLES.

It appears, then, that the more simple stomachs are those which are intended to digest animal food, as being the most easily converted into nourishment; and that the more complex, either afford additional means of pressure or division, or require an additional period for the food to be acted upon.

DR. A.

This is quite the case; and nature has modified, in various ways, the process of digestion, and suited the kind of stomach to the description of food on which it is intended to act. But we must defer the further prosecution of this subject to another opportunity.

CONVERSATION XVI.

DIGESTION CONTINUED.

ABSORPTION.

HARRIET.

I WAS just going to remark, at the conclusion of our last conversation, that I wondered, considering what a powerful substance the gastric juice must be, to be able to dissolve the various matters which are employed as food, how the stomach itself is able to resist its influence.

DR. A.

Living animal matter has a power of resistance which dead does not possess; and examples are occasionally found, in which the gastric juice, after death, both in man and some quadrupeds, has corroded holes in the stomach, which was unaffected by it during life. It is in the same way that worms, botts, and such sort of animals are unaffected by a residence in the stomach and alimentary canal, in which they obtain their nourishment; but if they were to die, they would then be

unable to resist the influence of the digestive fluid, and would be dissolved, like any other extraneous substance.

CHARLES.

Has the gastric juice, when examined out of the body, any very strong or caustic characters?

DR. A.

None by which you can infer any thing like the effects which it is capable of producing. It does not differ much in appearance from saliva; and in sensible qualities it is slightly bitter and saline. It possesses, out of the body, in some degree the same property of reducing substances to a pultaceous, chyme-like mass, which it has in the stomach.

SOPHIA.

But how is the gastric juice procured for the purposes of examination?

DR. A.

Sometimes it has been obtained from the stomachs of animals after death, who had fasted a good while previously; sometimes by making animals swallow portions of sponge, which were withdrawn on being filled with the fluid of the stomach; and sometimes by the action of vomiting on an empty stomach. The gastric juice has the power of coagulating, which seems to be the first

process of digestion in such substances, as milk, which admit of coagulation. Hence an infusion of the fourth, or digestive stomach of calves, as being imbued with gastric juice, is usually employed to coagulate milk; and so small a quantity answers the purpose, that seven grains, infused in water, were found to afford as much fluid as coagulated 100 gallons of milk; that is, more than 6857 times the weight of the substance employed.

CHARLES.

Then it is probably of an acid nature, since acids so remarkably possess this property.

DR. A.

So little is this the case, that it has been found that a portion of the stomach of a calf, if even kept for some time in an alkali, still retains its characteristic property.

HARRIET.

Is this property of coagulating common to all stomachs?

DR. A.

Such seems to be the case; for Mr. Hunter found it to exist in the stomach of the boar; in the crop and gizzard of fowls; and in the stomachs of sharks, salmon, and thornbacks. It appears that it is owing, in all animals, to the secretion of the gastric

juice, though its mode of producing this effect is unknown. The gastric juice has likewise a remarkable power of checking putrefaction in any half putrid aliment which may be taken into it; and the same power is exercised on similar substances out of the body.

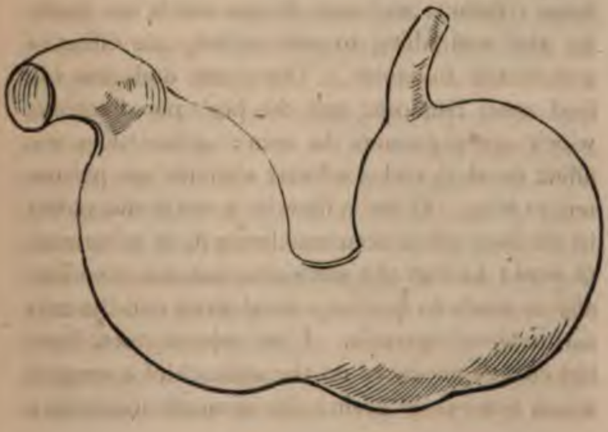
HARRIET.

When animals swallow flesh and bones with undiscriminating voracity, is the gastric juice able to dissolve the bones?

DR. A.

The stomachs of dogs and hyenas have very remarkably that property; and the teeth of the latter are most formidably adapted to crushing bones, and preparing them for the action of the gastric juice. Even ivory, and the enamel of the teeth, are dissolved in the stomachs of dogs; and that of a hare has dissolved an onyx, and diminished a louis-d'or. But the external husk of vegetables very singularly resists the operation of the gastric fluid, as in the case of oats with horses; or the seeds of apples and other fruit with man; but when these substances are bruised, or triturated, they are then acted upon in the usual way.—The endeavours of chemistry to ascertain the nature and mode of operation of the gastric juice, have hitherto been very unsuccessful. Its operation seems to be very much confined to the food which

is contact with the surface of the stomach, and it is in greatest force at the larger end, which is on the left side of the body, as you may see by the sketch. The mass of food is slowly passed on by the muscular action of the stomach, to the smaller end, and from thence to the pylorus; and it appears that any new food which is added, is kept separate from the old, being in the centre of the latter, and therefore not subjected to the action of the gastric juice, till that first received has been converted into chyme. I have already mentioned to you the division into a right and left portion, which some physiologists consider as occurring during digestion. The sketch which I now shew will enable you to form an idea of this.



CHARLES.

The power of converting substances of various kinds into animal flesh, of the same appearance and nature, is a wonderful operation, which seems to be intended to make every thing useful; for if animal flesh could only be produced by animal flesh, the whole of the vegetable kingdom would, as far as nourishment goes, be altogether useless.

DR. A.

And yet you are not aware still, of the full extent of the provision which exists for the support of animal life. For instance, there are substances which would act as poisons to man, which are salubrious, and nutritious to many of the brute creation; and some things which are grateful and nourishing to one animal, are offensive and hurtful to others. The sheep and goat will feed upon hemlock, and the pig upon henbane, which are poisonous to man; opium does not affect the dog, and yet bitter almonds are poisonous to him. There is likewise a wonderful power in the stomach of accommodating itself to varieties of food; so that the graminivorous can occasionally be made to feed on animal food, and the carnivorous on vegetable. I have already mentioned the change produced on the stomach of a sea-gull which was fed on grain; the stomach acquiring a

great increase of muscular power, which the change of food rendered necessary.

But man, of all animals, possesses the greatest power of accommodation to the varieties of aliment which different climates afford. In the high latitudes, his food is entirely animal, and often of the most forbidding nature, according to our conceptions; as raw whale, seal blood, dried herrings moistened with whale oil, &c.; while in the torrid zone, he is supported principally by fruits and vegetables. Though we are the creatures of habit, the same individual can likewise bear great varieties of sustenance; and with regard to the particular effects of animal or vegetable diet on the physical powers of man, we have examples of strength, activity, and bravery, in the Greeks and Romans of ancient times, and in the Irish and Scotch of modern, under the employment principally of vegetable food.

For the purpose of ensuring the proper support and nourishment of the body, nature has wisely given the strong impulse of hunger and thirst, by means of which animals are led, by a law of continual operation, to look out and procure for themselves, a proper quantity of food. Some have thought that the immediate cause of hunger was mere emptiness, by means of which the coats of the stomach either spontaneously, or through the means of the folds produced in the villous coat, by

the contraction of the muscular, rub against each other, and produce the peculiar sensation. Others are of opinion, that it is attributable to a certain degree of irritation produced by the action of the gastric juice; and others, that it is to be considered as a sensation depending on sympathy with the wants of the system at large. None of these opinions appear to be sufficiently established; but the immediate cause of the sensation is not well understood: that it is however connected, in some obscure way, with the nervous system, seems to be obvious from the circumstance, that any powerful affections of the mind, particularly grief; any interesting and absorbing employments; and various narcotic substances, as opium, tobacco, betle, or ardent spirits, will suspend or diminish the disposition to take food. The existence of a mechanical agency in producing the sensation of hunger, seems to be likewise contradicted by the well-known fact, that appetite will often entirely disappear, if the hour of taking food is passed over; though one has heard that the swallowing balls of earth, and the application of tight ligatures round the body, will, in some cases, deaden the feeling of hunger. — A good deal of the same difficulty attaches likewise, to an endeavour to account for the existence of thirst. This sensation seems to be much connected with various derangements of the system, and it is but seldom

dependent on absolute privation of drink, as hunger is of food. We principally refer it to the mouth and fauces; yet in that extraordinary case which I mentioned to you, of a wound in the gullet, no quantity of water taken into the mouth, and passed out at the wound, could quench thirst; but a small quantity of fluid, particularly weak spirit and water, injected into the stomach, remarkably abated it.

When the food has remained as long in the stomach as is necessary for its conversion into chyme, an action of its muscular coats takes place, by means of which it is passed on to the pylorus, and through this into the intestines; and here I may observe generally, that in graminivorous animals, the canal is longer than in man and carnivorous animals, in order to afford still further time for assimilation, and for the nutritive part to be taken up. In the lion, the intestinal canal is about 4½ times the length of the body; in man about 5½ times; but in the horse it is about 11 times, and in the antelope 18 times.

CHARLES.

Is there any distinction made between the different parts of the intestines?

DR. A.

The intestines are divided into the small and large. The small, are those which are immediately

continuous with the stomach. They consist of, 1st, the *duodenum*, which is so called from its being about twelve inches long; 2d, the *jejunum*, from its being often found empty; and, 3d, the *ileum*, from its occupying the iliac region, or that between the two hip bones. — The small intestines are mostly occupied in perfecting the assimilation of the food, and in affording an opportunity for its absorption. — The large intestines are a continuation of the small, and are termed, 1st, the *cæcum*, which is so called from its being, in some degree, a cul-de-sac; 2d, the *colon*, which nearly encircles the abdomen, and terminates in, 3d, the *rectum*: and these three last are the receptacles of the food, after having parted with most of its nourishment, and become excrementitious.

CHARLES.

Does the structure of the intestines bear any analogy to that of the stomach?

DR. A.

It is very similar, there being a villous or mucous lining, followed by layers of longitudinal and circular fibres, and then by an external covering, which is common to all the organs contained in the abdomen. By means of these muscular fibres, the food is gradually carried downwards, by a sort of gentle vermicular motion, which is technically termed the *peristaltic motion* of the intestines. Next

to the stomach, the most important change which the food undergoes is in the first intestine, the duodenum, where the bile and pancreatic juice are added to it; but over the whole course of the canal, fluids are poured into it from the exhalent vessels, for facilitating the conversion of the food into nourishment, or for covering and defending the inner coat from injuries by the occasional passage of any irritating matter. The *bile* is a yellow bitter fluid, secreted from the liver, and poured into the duodenum at a short distance from the stomach. There is also a little receptacle for the bile, which is called the *gall-bladder*, and in this, gall-stones, when they occur, are formed, which often give extreme pain in their passage into the intestine.

SOPHIA.

It is very usual for persons to be bilious; and I presume this is from some disease in which the bile is concerned.

DR. A.

Bilious, and nervous, are two terms which have no well-defined meaning annexed to them. Persons call themselves, and are often termed bilious, who are subject to some one or other of the various affections in which the stomach or bowels are concerned; but in by far the greater number of such complaints, the liver is only concerned as

a part of the organs of digestion, and in no other, or primary way.

HARRIET.

People are often said to have affections of the liver; and, indeed, one would imagine, to hear of the frequent attacks of this organ, that it is the most susceptible one of the body.

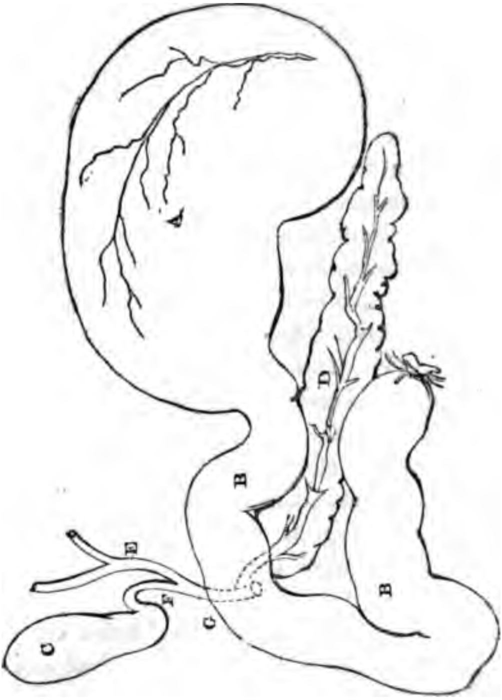
DR. A.

It is a very important organ; and, in warm climates, it is particularly liable to disease. In the more temperate, however, it is much less so; and it often happens, that diseases are referred specially to the liver, which are only affections of the large intestine, the colon, which is contiguous to it. The LIVER is a large, firm, and dusky red-coloured organ, which is on the right side of the body, lying directly under the ribs, separated from the chest by the diaphragm, and not capable of being discovered by the touch, unless it is enlarged. It is divided into two principal parts or lobes, and the left one lies over the stomach. It is liberally supplied with blood-vessels, and from the extremities of these vessels the bile is secreted, which arises in small tubes, that unite into larger ones, and then into a duct, by which the bile passes either directly from the liver into the intestine, or into the gall-bladder, and from thence is thrown into the intestine. But the bile, in the latter case, is of a thicker and darker description than when

[redacted]

it comes from the liver directly. There is a curious structure which nature adopts, to prevent a tube, which is destined to throw out a fluid from any organ, from allowing its return. This, it is clear, would be liable to happen, if it entered at a right angle, or any thing like it; but, instead of doing so, it pierces the external coat very obliquely, then passes on between the coats, and enters the intestine in such a way, that the inner coat of the latter acts as a valve, and is shut against pressure from the intestine. A similar structure is adopted in throwing the *pancreatic juice* into the intestine. This fluid much resembles saliva, and has an operation in promoting the assimilation of the food, which is but little understood. It is secreted by the PANCREAS OR SWEETBREAD, an organ which lies across the abdomen, and is of a glandular structure; and it is thrown into the intestine through a duct having an opening common to it and the bile. You will be able to understand the relative positions of the stomach, gall-bladder, duodenum, and pancreas, from the sketch which I now shew you, in which A is the stomach; B B the duodenum; C the gall-bladder; E F G the gall ducts, of which E is the hepatic duct, which brings the bile from the liver both to the gall-bladder and the intestine; F the cystic, which takes it to the gall-bladder; and G the common duct, which carries it both from the liver and the

gall-bladder into the intestine, by the dotted tube, which unites with a duct from D, the pancreas, to pour the bile and pancreatic juice by the same common opening into the intestine B. When a gall stone passes into the intestine, it is clear that its course must be from the gall bladder C, through the cystic duct F, and the common duct C, into the duodenum, at the place where the two tubes unite.



In the sketch which I shall next shew you, the ribs are supposed to be removed, and also the coverings of the abdomen, so as to give a general view of the contents of the cavities of the chest and abdomen.

Those of the latter, only, come under consideration at present; but I shall give you the references to the whole at once.

No. 1. is the trachea, or windpipe;

No. 2. the internal jugular vein;

No. 3. the subclavian vein;

No. 4. the vein called the upper vena cava;

No. 5. the right auricle of the heart;

No. 6. the right ventricle of ditto;

No. 7. part of the left ventricle of ditto;

No. 8. the aorta, or large artery;

No. 9. the pulmonary artery;

No. 10. the right lobe of the lungs;

No. 11. the left lobe of the lungs;

No. 12. is the diaphragm, or separation between the chest and abdomen: and the following are viscera belonging to the abdomen, viz.

No. 13. the liver;

No. 14. its round ligament;

No. 15. the gall-bladder;

No. 16. the stomach;

No. 17. the small intestines;

No. 18. the spleen.

In the sketch which I have just shewn you, the large intestines are supposed to be removed; but

you may judge of their position from another sketch, in which A designates the commencement of the colon, with the ileum attached to it at its bottom, ascending past the liver; and B, the arch of the colon, passing under and close to the stomach: at C, the colon forms what is called the *sigmoid flexure*, from a resemblance of its curve to the letter sigma, and terminates in D the rectum.

Over the whole of the intestines, I must observe, is thrown a thin double membrane, often containing much fat, which is termed the *omentum* or *cawl*; and the substance by which the various intestines are joined together is called the *mesentery.*

CHARLES.

There is, I suppose, some mode by which the liver is supported, for its weight would otherwise be likely to carry it downwards?

DR. A.

This is effected, both in the liver and other organs, by what are termed *ligaments*, by means of which these are tied or united to some fixed parts. In the case of the liver, its principal adhesions are to the diaphragm, which, as I mentioned before, is the partition between the cavity of the chest and the abdomen.

CHARLES.

Are these ligaments fixed to any particular part of the diaphragm or liver? I can understand how a ligament is fixed to a solid body, as a bone; but it is more difficult to conceive an attachment to a soft part.

DR. A.

This involves a very curious and important part of abdominal structure, which I must endeavour to explain to you. The whole of the walls of

the cavity of the abdomen, including the diaphragm, are lined with a thin fine membrane, called *peritoneum.* This membrane affords an external covering to the liver, spleen, stomach, and intestines; and by the doubling over, which necessarily occurs at various places, there is a binding of the different parts together. Thus at the diaphragm, the peritoneum, instead of covering the whole of this partition without interruption, is reflected over the liver; and if you can conceive the two surfaces brought around it so as to unite, you would then have a ligament, or bond of union formed, and the large heavy body of the liver prevented from descending. It is in this way that various doublings or folds of the peritoneum are formed, which are important in the minuter anatomy of the abdomen.

CHARLES.

I must own that I cannot quite understand the account which you give of the peritoneum; or how it can afford a covering to the viscera of the abdomen, without being in separate pieces.

DR. A.

If you suppose this room to be lined with chintz, or any other thin material, how would you contrive to cover the cabinet, which stands at a little distance from the wall, by a mere prolongation or fulness of the chintz?

CHARLES.

We must bring it round the cabinet first, and then make it firm to the wall.

DR. A.

That would merely cover the front and two sides of the cabinet, while the back of it is uncovered, as well as the wall which answers to the back. This does not accord with the description which I give you of the peritoneum, that it covers the walls as well as the furniture of the abdomen.

CHARLES.

If we carried the chintz round the cabinet, and brought the two ends together behind, we should cover the cabinet; and then the two ends, by being separated, would cover the wall completely behind it.

DR. A.

This is the mode in which the peritoneum covers the abdominal viscera and the walls of the containing cavity. If you suppose separate pieces of furniture, all which require covering by means of the chintz, you will see clearly that an uninterrupted prolongation of the same material, may give a covering to various separate, and very irregular bodies.

HARRIET.

Then these bodies must all be joined together

by a double fold of the peritoneum, just as it happens that there is a double fold of chintz at the back of the cabinet joining it to the wall.

DR. A.

This is exactly the case; and you see that there is, by this means, an attachment of the cabinet to the wall, just as happens in the abdomen, where there is an attachment of the liver, and the other viscera, to neighbouring parts, by the doublings of the membrane, which affords them all a covering. If you were to suppose all the furniture of the room covered with prolongations of the same lining, there would then be various doublings from the walls or floor, in order to accomplish the purpose. In this way, the various meanderings of the intestines are held together; and the doubling by which this is effected is termed the *mesentery*. Where strength of support is required, there are firmer and tighter doublings provided; where attachment only is wanted, the covering is loose. — It is merely necessary to notice the SPLEEN, which is another of the viscera of the abdomen, and lies, as I have already mentioned, on the left side of the body, contiguous to the stomach, to which it is attached by blood-vessels. It is of a dark purple colour, very full of blood, of an irregular, flattened, oblong figure, and with no perceptible duct. Its uses have not yet been ascertained; and

that they are not of prime consequence in the animal economy, is apparent from the circumstance, that it has been removed from dogs, without affecting their health. It is apt to be enlarged by residence in a tropical climate; and in this case forms what has been vulgarly termed the ague cake, from its frequently being the consequence of intermittent complaints. — In addition to the abdominal viscera which I have mentioned, I may remark that there are two or three other organs not suitable for elucidation by conversation, and which must, if they are made the subject of attention, be studied in books.

CHARLES.

It appears from what you have stated to us on the subject of digestion, that this process consists of two series of operations; one occurring in the stomach, by which the food is converted into chyme; the other in the bowels, by which it is converted into chyle; for I presume that chyle is never to be found in the stomach.

DR. A.

It makes its first appearance in the duodenum, after the mass which has been transmitted from the pylorus has been mixed with the bile and pancreatic juice; but it is continued to be formed during the whole course of the small intestines. Over the whole interior of these intestines, and more sparingly in the large ones, minute vessels,

called *lacteals*, as I mentioned to you, open, for the purpose of taking up the chyle. They carry it on to the mesentery (that part of the doubling of the peritoneum which unites the folds of the intestines together), to several series of small glandular bodies, existing in the substance of the mesentery. Over them the lacteals are divided into minute ramifications, unite again into large branches, are again dispersed over other series of these glands three or four times, and then again produce a small number of larger trunks, which join in forming one long one; which is called, at its commencement, the *receptaculum chyli*, or receptacle of the chyle, and in its continuance, the *thoracic duct*. These, together, form a small membranous, tortuous canal, several inches in length, about the thickness of a small quill, and a little wider at its commencement, where it is termed the receptacle of the chyle, than in its progress. It lies close to the spine, accompanies some of the large blood-vessels, and, ascending to the upper part of the chest, delivers its contents into a large vein near the heart, called the left subclavian; and these contents then form a part of the general mass of blood. The whole process is termed ABSORPTION. You will be able to form some idea of the course of the thoracic duct, from the little sketch which I now shew you, in which

No. 1. is the left subclavian vein;

2. the internal jugular vein ,


2
1
10
5
9
4
3
3
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3
8
6
7

3. part of the vein called azygos, or vein without a fellow;
4. part of the descending aorta, or great artery;
5. the subclavian artery.
6. lacteals entering the receptacle of the chyle;
7. lymphatics entering ditto;
8, 9. the thoracic duct;
10. the entrance of the thoracic duct into the subclavian vein.

HARRIET.

How very simple and intelligible you have made this route of the chyle to the circulating system. But is the chyle, in its milky form, fitted at once to unite with the blood, and perform its various functions?

DR. A.

By no means. It has to pass through the circulation; and there you will find, that there are some processes to which the compound fluid must be subjected, before it is adapted to nourish the body.

CHARLES.

The divisions which the lacteals suffer in the mesenteric glands are, I presume, intended to complete the adaptation of this fluid to entering the blood.

DR. A.

Such a purpose is exceedingly likely; but we

know very little of the particular structure of glands, so as to be able to form any conjecture as to the mode in which nature makes them useful. The proper and pervious state of the mesenteric glands is essential to the health of the body; for in case of their obstruction, or of their want of due action, the chyle is imperfectly taken up, or unduly elaborated; and as the system is in this way not adequately nourished, emaciation takes place. Mesenteric disease is therefore a very formidable complaint, and is such as children are particularly liable to, more especially in large towns; though it is very probable that complaints ascribed to the mesentery alone, belong to much of the process of digestion and assimilation.

CHARLES.

The mouths of the lacteals take in their contents, I suppose, by capillary attraction; but I cannot understand, in this case, why they should not imbibe any fluid, whether nutritive or not, which may be applied to them.

DR. A.

There seems to be a power of contraction in those vessels, by means of which they refuse entrance to any substance of an injurious nature.

CHARLES.

But in what way are the contents propelled? for

capillary attraction would only operate while the vessels were of a certain size.

DR. A.

Throughout both the lacteal vessels, and thoracic duct, valves are placed, which prevent the fluid which has once entered them from regurgitating; and a valve likewise exists for the same purpose, at the termination of the thoracic duct, in the great vessels which I mentioned to you that it joined. These valves give a knotted appearance to the lacteals and thoracic duct, and seem to be produced by a doubling or folding of the inner membrane of the tube. In this way the return of the chyle is prevented; but there is likewise a contractile power allotted to the lacteals and thoracic duct, by means of which a contraction takes place over their contents, so as to propel them forward. If there had not been valves, the action might have thrown the contents either way, and thus part of such action would have been lost; but with this structure, all the contractile force is employed in propulsion.

CHARLES.

There must then, I suppose, be a muscular structure in the lacteals and thoracic duct, to produce this effect.

DR. A.

The coats are too thin to admit of such a struc-

ture being discovered by the eye; but the vessels, though very thin, and indeed imperceptible when empty, are very strong, and have a power of emptying themselves even after death; since the lacteals which may be visible on the mesentery of animals immediately after death, from having chyle in them, soon cease to be so, from the chyle being passed onwards. The thoracic duct likewise, on being opened, has been known to throw off its contents, like blood from a vein. It is to be observed, that there is a similar structure both in the veins and the lacteals, which assists this motion, viz. that the trunk is smaller than all the branches united; so that an acceleration is given to the current, the nearer the fluid approaches to the trunk of the absorbing vessels. There is still, however, a good deal of difficulty attaching to the mode in which the motion of the chyle takes place, and an ingenious idea has lately ascribed it, in some degree, (as I shall have occasion to mention to you, when I speak of the mode in which the circulation of the blood is carried on,) to the effects of atmospheric pressure operating during the act of inspiration.

HARRIET.

It is certainly a very extraordinary circumstance, that animal and vegetable food, which are so very different in their nature, should both of them in

time be equally converted into blood, and, through the medium of this, into all the varieties of substances which exist in the animal body. If the ultimate elements of both were the same, there would be no difficulty in the idea; but if this is not the case, it seems to be by a sort of transmutation, hardly less perfect than that of lead into gold, by which grass, for example, is so altered in the digestive organs, as to be capable of conversion into muscular flesh.

DR. A.

We can hardly admit the production of a new substance, without the materials being afforded of which it consists; and if we cannot account for the access of these materials, it only evinces that our knowledge of the ultimate analysis of the bodies from which such new substance was derived, or our acquaintance with the other sources from which its component parts might originate, are not sufficiently accurate. The great general distinction between ordinary animal, and ordinary vegetable matter, is the absence or paucity of azote in the latter; for by ultimate analysis, oxygen, hydrogen, and carbon are found to be common to both, though in unequal quantities. What may be the source of that large portion of azote, which forms so important a feature in animal composition, is a matter of question;

and whether it may arise from the decomposition and new combination of substances, which we have been in the habit of regarding as simple, has not yet been determined. The most accurate researches of some of our most scientific chemists have pursued the food from its entrance into the stomach, through all the successive changes which it undergoes there, and in the small intestines, and also in various parts of its course, as chyle, up to its combination with the blood; and it has been found that material changes of nature in the nutritive part of the aliment take place through every part of the progress, by means of which the vegetable matter becomes more and more animalized, and the animal, more and more made to approximate to the nature of blood. It is very probable that varieties may even occur between the precise nature of the gastric juice and other secretions to which the food may be exposed in its progress, so as to assist in the more ready animalization of the vegetable matter; and as we exist in a fluid, the atmosphere, of which the larger part consists of azotic gas, it has been rendered probable, (as we shall find on the subject of respiration,) that a supply of azotic gas may take place from the atmosphere, which may have some effect in making up the balance rendered necessary by the use of vegetable aliment alone. The transformation of vegetable food into animal matter, is

still, therefore, a subject of great difficulty with physiologists.

CHARLES.

The production of the solid material of bones, the phosphate of lime, must, I should conceive, be a matter of some difficulty in the theory of digestion; unless the food, whether animal or vegetable, be considered as affording sufficient for the purposes of the system.

DR. A.

Lime is one of the most universally diffused bodies in nature, and it would not be difficult to suppose, that enough of this might be afforded by the aliment for ordinary purposes; but then there are some animals, as the testaceous and crustaceous, in which so large a quantity is requisite, as to make it impossible to consider the supply as depending entirely on the food taken in. Some accurate observations have been made as to the quantity of calcareous matter produced in eggs in a certain time, by a hen fed in a known way; and it has been satisfactorily ascertained, that more calcareous matter was elicited, than could be accounted for by that which was received as aliment. Here, therefore, there was either a generation of such calcareous matter by the powers of the system; or this substance must be a compound body, formed by some decompositions, or new combinations of substances,

whose chemical nature and mode of combination have not been sufficiently understood. Similar difficulties have occurred in the vegetable kingdom; for in answer to a prize-question proposed by the Berlin Academy, to determine the constituents of the different kinds of corn, and to ascertain whether their earthy part is formed by the process of vegetation, it was at length discovered by Schrader, a Prussian, that seeds will grow and produce corn, yielding as much, or more earthy matter than the original seed, when removed from all contact of earth, and watered merely with distilled water. The experiment was made on seed planted in sulphur, placed in a garden, at a distance from all dust, in a box to which the light and air had free access, but from which all dust and rain were carefully excluded. In confirmation of the same extraordinary circumstance, Saussure found, that plants growing in a calcareous soil, which contained little or no silica or flint, will, nevertheless, yield a considerable portion of that substance; and other chemists have discovered in the ashes of some descriptions of pines, more than 65 per cent of lime, when no traces of this substance could be found in the soil. All these circumstances, therefore, discover that the powers of chemistry are inadequate to detect the processes which are continually carried on in the animal, as

well as the vegetable economy, for supporting life and promoting growth.

HARRIET.

You spoke, when you were on the subject of the brain and nervous system, of galvanism having some influence on the function of digestion. In what way does it bear upon the process?

DR. A.

Digestion is found to depend on a certain influence propagated from the brain to the stomach, through the medium of a particular nerve which passes down the neck and back, and is called the par vagum, or wandering pair of nerves. If these nerves are divided, and a portion of them removed, digestion is suspended; but it is restored on substituting galvanism for the natural nervous energy, and hence it has been conceived, that nervous and galvanic influence are identical.

In mentioning to you the lacteal vessels, I have omitted the notice of another very important part of the absorbent system; namely, the *lymphatic vessels*, the contents of which are carried into the blood, partly through the medium of the thoracic duct (No. 8, 9. Page 209.), and partly by separate junctions with the large veins themselves, near the place where that duct joins the subclavian vein.

HARRIET.

I recollect that you gave us an outline of the lymphatic system, when you conversed on the subject of the bones; and I well remember how curious we considered the continual deposition and absorption of the various parts of the body, which you then mentioned to us.

CHARLES.

By means of the lymphatics, the body seems to live upon itself, since the fluid which they contain, is thrown into the mass of blood, with what is intended for nourishment. But is there any similarity in the structure of the lymphatics, compared with the lacteals?

DR. A.

A very considerable one, both in appearance and texture; and both sets of vessels pass through glands, and are endowed with valves, in order to prevent regurgitation. The glands become apparent, as well as the course of the lymphatics themselves, when the extremities of these latter are irritated, or in any other way injured. For instance, when leeches are applied to any part, the bites will occasionally fester, and in this case, if the part should be the hand, red lines will be seen extending up the arm, and running to the arm-pit, in which a small painful knot may be felt, which is an inflamed lymphatic gland. Medical gentlemen have

sometimes severe affections of this kind, from accidental cuts or scratches got in dissection.

CHARLES.

Would the lymphatics be capable of being seen as white lines immediately under the skin, as you have mentioned to be the case with the lacteals in the intestines and mesentery?

DR. A.

The lymphatics are always invisible, for the fluid which they contain is pellucid like water, and not of a milky nature like chyle; and the trunks into which all of them unite, may be seen to pour a watery material into the thoracic duct, (No. 7. page 209.) or into the subclavian vein when they terminate directly in that.

SOPHIA.

Except for this proof, it would be very difficult to conceive the existence of such a minute system of vessels, containing a transparent, and therefore an invisible fluid.

DR. A.

It is not, however, left to mere general inference, however probable, to conclude concerning this system of vessels. By great nicety, a lymphatic vessel is capable of being discovered, and of having a very small tube fixed in it, communicating,

or continuous with a larger one containing mercury. The weight of the mercury forces on the minute stream, first into branches, and then into trunks, till not only the existence of lymphatics is discoverable in all parts of the body, but their union in glands, their departure from them again in branches, their subsequent union in trunks, and the congress of their trunks in a common centre. In this way, the whole body has its lymphatics filled with mercury, so as to exhibit an extensive series of vessels over every part of it, communicating freely with each other; so as that if one gland is obstructed, the fluid may be carried on, without interruption, by uniting branches, which have passed through other glands. I may mention to you, that lymphatics have not yet been discovered in the brain; but there can be no doubt of their existing there, as well as in other parts of the body.

SOPHIA.

I take it for granted, that lacteals and lymphatics exist in all animals.

DR. A.

An absorbent system has been discovered in the mammalia, birds, amphibious animals, fishes, and insects, and something of a similar kind must also exist in the lowest orders of the creation. Throughout the mammalia, there is a very great resem-

blance in the lacteal and lymphatic system; and in all of that class, the chyle is white and milky. In birds, the chyle is transparent, as well as the lymph; and in them, as well as amphibious animals and fishes, there are few or no glands and valves. There are various differences in animals, in the direction and course of the lymphatic vessels, and in the variety of shape and number of the trunks in which they terminate.

HARRIET.

There seems to be this curious difference between the action of the lacteals and the lymphatics, that the former only take up one particular substance, chyle, while the latter appropriate to themselves every thing with which they come into contact. It seems as if they blended together all the materials of which the body is composed, whether bones, flesh, or membrane, into one general and uniform mass, to be again and again made subservient to the purposes of the animal economy.

DR. A.

This is the case; and a singular and beautiful circumstance it is, that there should be such a great and unceasing activity employed, as I before explained to you, over every part of the system, in moulding it to its particular form, in taking off what is injurious, and in contributing to a due balance of

action in the various parts of the animal body. But the lymphatic vessels, it is necessary to mention to you, not only carry back into the system what originally belonged to it, but from their diffusion on the skin, have the power of imbibing, sometimes spontaneously, and sometimes by means of friction, substances which come in contact with the skin. Thus portions of mercury, lead, and other deleterious substances, can be taken in, and produce well-marked effects on the system, through the medium of the skin; and moisture can be absorbed by the skin, either when the body is immersed in water, or in air, though in various degrees according to the condition of the animal, and the circumstances under which it is exposed.

CONVERSATION XVII.

OF THE CIRCULATION OF THE BLOOD.

DR. A.

We have followed the course of the nutritive part of the food, up to its introduction into the circulation; and in natural order, we come now to consider the mode in which the circulation of the blood is carried on.

The heart and blood-vessels are the organs employed in this process; and these last, I have already mentioned to you, consist of *arteries*, which are employed to transmit the blood to the various parts of the body from the heart; and *veins*, which are employed to return it to the heart.

HARRIET.

These vessels, I suppose, are of the same nature, though they differ in some degree in their office.

DR. A.

In that supposition you are much mistaken. The arteries are of a much thicker, firmer, and

more elastic nature than the veins, and are moreover distinguished by their pulsation.

SOPHIA.

The pulse, then, which is felt at the wrist, arises from an artery: but how does it happen, that we do not feel pulses in other parts of the body, as arteries must be very extensively diffused which we see that veins are?

DR. A.

Arteries are in general deep seated, for the purpose of their protection from injury. There are, however, some places, where they are readily felt, and their pulsation even seen, as for instance in the temple, where small branches arise from a trunk which passes up close by the ear. In some other places they may likewise be felt with a little care, as in the whole course of the arm, from the shoulder to the elbow. The force of arterial pulsation may be readily imagined, when I tell you, that the motion of the leg which is to be observed when one leg is placed across the other, arises from the pulsation of an artery in the ham, and which it would be difficult, if not impossible to stop, by any weight which we might employ for the purpose.—The general view of the circulation is, that the heart transmits the blood to the different parts of the body by the arteries,

which is returned by the veins to the heart, to be again circulated. This is called the *greater circulation;* but at the same time it is to be observed, that there is an intermediate, or *lesser circulation*, to which it is also to be subject through the lungs.— The mixture of chyle and lymph enters the veins; and the veins convey the blood to the right side of the heart, from whence it is carried through the lungs. It is then brought back to the left side of the heart, and forthwith transmitted by the arteries all over the body, to be brought back by the veins, and to be continually subject to a repetition of the same career.

HARRIET.

Then there appears to be a sort of double circulation; one side of the heart circulating the blood through the lungs, the other over the body. But I wonder why the lungs should not derive their blood and nourishment in a way similar to other parts of the body, through the medium of the arteries from the left side of the heart.

DR. A.

The nourishment and support of the lungs are effected by means of arteries, in the way which you have suggested; but you must remark, that when blood from the veins is first received into the heart, with the recent addition of chyle and

lymph which have been made to it, it is not fitted for the support of the system; and hence it is, that the lesser circulation takes place.

HARRIET.

Does the blood then differ in different parts of the body? I thought that it had all been alike in nature, as it is in appearance.

DR. A.

But it is not alike, either in nature or appearance; for that which is contained in the arteries, is of a florid red, or scarlet colour; that which is contained in the veins, is of a dark, or modena red; and the former only is fitted for the nutritive purposes of the system.—When the venous blood is received into the heart, it is of a very dark colour. It circulates through the lungs, and it returns florid. It is in this organ, therefore, that it becomes properly, and finally assimilated. It returns back proper blood, is circulated, furnishes the materials for the growth of parts, and for the formation of the various secretions of the body; and after serving these purposes, its nature is changed, it is returned by the veins, of an altered colour and character, and unable further to nourish and support. It receives the addition of fresh materials from the food, is then elaborated in the lungs, and again undergoes the same process.

CHARLES.

Has the change which the blood undergoes in its circulation through the lungs, been ascertained?

DR. A.

The changes produced in the lungs depend principally on the operation of the air in respiration. This, however, will come under our more particular notice, in considering the lungs, and the functions to which they are subservient. We must now examine the great organ of circulation, the heart.

THE HEART is principally composed of irregular fleshy fibres, of considerable strength. It is lodged in a sort of bag, called the *pericardium*, which usually contains a portion of watery fluid in it, called the water of the pericardium. The heart and lungs are both of them contained in the cavity of the thorax, or chest. This cavity is, as I have stated before, separated from the cavity of the abdomen by the *diaphragm*, which is a muscle capable, by its contraction and expansion, of enlarging or contracting the cavity of the chest. It is so placed as to be concave outwardly: that is, towards the abdomen; and convex inwardly, towards the chest; and has, on this account, been aptly enough compared to the shape of the bottom of a wine bottle, which ascends some distance into the body of the bottle, just as the

diaphragm does into the body of the chest. The chest is divided, from behind forwards, into two parts, by a double membrane called the *mediastinum*, which, however, leaves rather less space on the left side, than the right. The *lungs* fill up the whole of the right side of the chest; but they divide the left with the heart, which occupies a considerable space in the front; as you may observe in the sketch which I shewed you at our last meeting. The *heart* lies in a somewhat oblique position across the chest, its apex or point being towards the ribs, on the left side; while its basis, or broadest part, is higher up, and towards the centre of the chest. It contains within it two cavities, or *ventricles*, one of which is called the *anterior*, or right, and the other, the *posterior*, or left ventricle. It has also at its basis, and communicating with their respective ventricles, two other cavities, called *auricles*, so termed from their resemblance to a dog's ear, one of which is designated by the name of the right, and the other by that of the left auricle. The heart may, therefore, be considered as constituted by the union of four hollow muscles; namely, two ventricles and two auricles, each of them having a power of acting separately on the blood, which passes through them; but the muscular flesh which makes up the ventricles, is very much thicker and stronger than that which constitutes the auricles.

But it is necessary to examine more particularly the mode in which the circulation is carried on through the heart; and in order to make myself more intelligible, I shall suppose this again to be divided into two separate parts, the one, that which transmits the blood through the lungs; the other that which conveys the blood over the body. Each of those parts consists of an auricle and a ventricle. Now the blood which has circulated over the body, is brought back to the heart by an ascending and descending vein, and is poured in a full stream into its right auricle. As soon as the auricle is full, it contracts on its contents, and forces them into the right ventricle. When this becomes distended, it likewise contracts, and pushes the blood throughout the lungs, by means of the pulmonary artery. This is the completion of the first circulation, and in the sketch which I have made, you will see that *a a* designates the ascending and descending vena cava, which unite in transferring their blood to the auricle *b*, which gives it up to the ventricle *c*, and this to the pulmonary artery *d*, and subsequently to the lungs, which ramify into various branches on each side of the sketch. After the blood has circulated through the lungs, and has had those changes produced in it which the lungs are destined to effect, the second circulation commences, by the blood being transmitted through the means of the

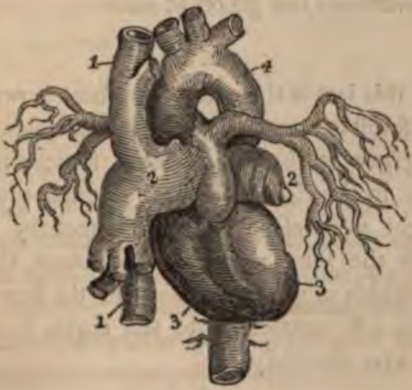
pulmonary vein *e* (or rather veins, for there are two from each lung) to the left side of the heart, where it enters the left auricle *f*, which contracts upon it, and forces it into the left ventricle *g*. This, in its turn, when full, contracts, and transfers it to the ascending aorta, or great artery, which is designated by the arrow ascending from the ventricle *g*; and this makes a curve called the arch of the aorta, from which various branches are sent out to supply the head and upper extremities; and descends in the descending aorta *h h*, to be diffused over the remaining parts of the body.

SOPHIA.

How exceedingly interesting is this detail. And I do not despair of understanding it, through the medium of the sketch that you have given us. If the two divisions were brought together, we should have, I suppose, a sketch of the heart as a whole?

DR. A.

Certainly; and for further illustration I shall show you another sketch, in which the heart is exhibited with its two sides joined, or locked into each other; though you will find it rather difficult to comprehend so apparently confused an assemblage of vessels as are here exhibited. In this sketch, 1 1 represent the large veins, the cavæ, answering to *a a* of the former one; 2 2 represent the right and left auricles, answering to *b f*, and having the pulmonary artery answering to *d*, expanding to the lungs on each side, between them; 3 3 are the right and left ventricles, answering to *c g*; and 4 is the aorta, answering to *h h*, the pulmonary artery answering to *e* being supposed to be concealed by the auricles.



SOPHIA.

Is the motion of the blood through the heart quickly performed? I suppose the beating of the heart must, in some way, be produced by the action of the auricles and the ventricles.

DR. A.

The beat of the heart evinces the contraction of its ventricles; and as the standard in a healthy adult is about 70 in a minute, you will understand in what a continual and rapid alternation of fulness and emptiness the heart is.

CHARLES.

But as the different parts of the heart act separately, we must only, I suppose, feel the beat

of one particular part at a time; unless, indeed, two movements can go on at once.

DR. A.

And this last is the case. The beat is produced by the forcible contraction of the ventricles, which, taking place at the same instant, forces the blood which is in the right side of the heart, that is, in the right ventricle, into the pulmonary artery, through the lungs; and at the same time the blood, which is in the left side of the heart, that is, in the left ventricle, into the aorta, to be dispersed over the body.

CHARLES.

But then the auricles receive their supply from the veins, just as frequently as the ventricles pass on the blood which has been transmitted to them. Is their action, of passing the blood on to the ventricles, capable of being felt?

DR. A.

The force which they are enabled to exercise, is much less than that of the ventricles; and so is the necessity for the exercise of force; and perhaps an inspection of the plan may afford you a reason for these circumstances.

CHARLES.

The auricles have only to propel the blood into

the adjoining ventricle; while the one ventricle has to transmit it through the lungs, and the other through the whole body.

DR. A.

Certainly; and, therefore, the force exercised, is not sufficient to produce an apparent beat. The action of the respective parts of the heart follow each other in rapid succession, and that of similar parts in each side have an accordance of movement. For instance, the large veins pour in the blood into the right auricles, at the same time that the pulmonary veins pour it into the left. Both auricles contract at the same time, and throw the blood simultaneously into the ventricle of their respective side; and I have already mentioned, that both ventricles act together, and form the beat. In professional language, the action, or contraction of the ventricles of the heart, constitutes its systole; the dilatation its diastole.

CHARLES.

It seems to be singular, that the contractions of the heart should only take place when the auricles and ventricles are full of blood. Is there any particular reason why this effect does not occur before these parts are filled, and thus more frequent pulsations produced?

DR. A.

In all muscles, there is, by the laws of nature, some particular stimulus, or exciting cause, which produces their action. This, with the heart, is the blood; and both the nature of the fluid, and distension produced by it, seem to be necessary to stimulate the muscular fibres to contract. The disposition to contract is so strong in the heart, that it continues in some animals for some time after death; and is readily excited by any mechanical irritation, even when separated from the body. Thus the little heart of a frog will continue its beat, many hours after the death of the animal, and its removal from the body; and the touch of a pointed instrument will restore it after it has ceased.

CHARLES.

As the auricles and ventricles are separate cavities in which the blood is always to go one way; there is, I suppose, some sort of valvular structure, as there is in the lymphatics, to prevent its regurgitation.

DR. A.

This is a beautiful part of the structure of the heart; and one, indeed, which was a principal means of leading the great Harvey to discover the real nature of the circulation; for as he found that there were valves, and that these allowed the passage of a

fluid in one direction only, he was thus led to discover the true principles of the blood's progress through the body. The veins pour, in a continued stream, their blood into the right auricle, forced on by the pressure of the blood behind; but between this auricle and its ventricle, and between its ventricle and the pulmonary artery, there are valves placed, which prevent any regurgitation of blood into the auricle from the ventricle, or into the ventricle from the artery. In the same manner, the blood flows, in a continued stream, from the pulmonary veins into the left auricle, being pressed on by that which is behind it; but between the left auricle and its ventricle, and between its ventricle and the aorta, valves are provided, as in the right side of the heart.

CHARLES.

Valves, I suppose, from their name, have some resemblance to folding doors, which open and shut, for the purpose of admitting or excluding.

DR. A.

Floodgates more nearly resemble them in office, with this difference, that valves, in the animal body, admit the passage of a fluid only one way, and thus preclude regurgitation; but they do this by their own action, without the adjustment which is necessary in floodgates.

SOPHIA.

I do not quite understand how a valve, which will let a fluid pass one particular way, can suffer the auricles or ventricles to get full in the manner that you mention. One would imagine that the blood would pass on through the valve, as soon as it was received into the auricle or ventricle, without remaining till the distension takes place, which excites them to action, unless there was some mode by which they could be kept shut.

DR. A.

There is much justness in your remark; but I must observe, that though the general circumstances relative to the heart and arteries, are very well known, some of the minuter points are still matters of speculation. When the ventricles contract, it is clear that the action of their muscular structure will shut the valves which open between them and the auricles, and thus suffer the blood to accumulate in the auricles; and it is very probable, that the elasticity of the coats, both of the pulmonary artery and the aorta, after passing on the column of blood transmitted through them by the ventricles; and the temporary interruption to its flow, which takes place on the cessation of the action of the ventricles, may give such a disposition to regurgitation, as may shut the valves, and allow the filling of the ventricles for the next impulse.

It is to be remarked, too, that on the relaxation of the arteries, a vacuum is produced, which is supplied by the blood from the auricles, and at the same time favours the shutting of the valves of the ventricles, so as to allow them to get filled.

CHARLES.

But if the contraction of the ventricles will shut the valves between them and the auricles, may not a contraction of the arteries shut the valves between the latter and the ventricles?

DR. A.

It has been a matter of question with some physiologists of late years, whether there is any actual diminution in the calibre of the larger arteries, after the current of blood has been passed through them; and it is thought by many, that the movement of the blood is produced by the action of the ventricles alone; and that the arteries, particularly the large ones, principally perform the part of pipes, to carry it on to the various parts of the body.

CHARLES.

But I thought that the pulse was produced by the swell of the arteries, owing to the increased quantity of blood thrown into them from the heart.

DR. A.

Such was long the prevailing idea; but doubts were thrown upon it by the consideration, that the vascular system must always contain the same quantity of blood in it; inasmuch as the same quantity makes its entrance into the heart from the venal extremity, as leaves it at the arterial extremity. It has likewise been stated, that in circumstances where there has been the power of seeing an artery uncovered, no dilatation or contraction in it were perceptible, though the impulse from the blood which was continually thrown into it from the heart, was distinctly felt on the coats of the artery, when the finger was applied to it. These, however, are minutenesses, which are rather inappropriate to the nature of our general considerations of physiological subjects.

CHARLES.

On this supposition, therefore, I presume, the impression communicated to the tube or pipe, as a solid elastic body, is felt by the finger.

DR. A.

This is thought to be the case, though it is rather difficult, on this hypothesis, to account for the beat being seen; unless, indeed, the mere vibratory motion communicated to the coats of the artery, should be apparent when propagated to the contiguous parts.

HARRIET.

I have often wondered what particular information about diseases the pulse can communicate; and perhaps you can give us a little idea of this, without at all risking our becoming doctors.

DR. A.

Whether the artery may be regarded as actually enlarged during its beat, or as merely communicating an impulse from the heart, the state of the pulse imparts to us a knowledge of the force and rapidity of the circulation, and gives us much other information relative to vascular action, which is important in enabling us to judge of diseases.

HARRIET.

Does the beat at the heart, and the pulsation at the arteries, take place at the same instant of time?

DR. A.

This is commonly represented as the case; but I think you will find, on feeling the beat of the heart with one hand, while, with the other, you feel the artery at the wrist, that they are not quite simultaneous.

HARRIET.

There seems, indeed, to be a very small, though an appreciable interval between them; but it requires great attention to make out this point.

CHARLES.

The heart seems to be a sort of forcing pump, which possesses a power that is necessary for carrying the blood over the body.

DR. A.

The relaxation and expansion of the ventricles, may be considered as producing what is equivalent to the vacuum formed in the pump, by means of which the water is raised; and the contraction of the ventricles acts the part of the depression of the piston; while in both cases there is a set of valves, which open in one direction only.

CHARLES.

The muscular power of the heart must be exceedingly great, since it can exercise the faculty of compression, to the extent of emptying its vessels completely, at every pulsation.

DR. A.

It is the most powerful muscular structure of the body, and it owes its great extent and force of contraction, to the particular disposition of the muscular fibres which form the ventricles. The right ventricle has to do no more than circulate the blood through the lungs; but the left has appropriated to it, the office of transmitting it over the whole system. It is therefore much thicker and stronger than the right; and possesses a very

peculiar structure to give it greater power; being constituted of two sets of fibres, disposed in strata, and surrounding the ventricle in a spiral form, the spiral disposition of the strata being in opposite directions. In this way, it is clear, that longer fibres can be employed, and that a smaller contraction of each set will be necessary, than under a different distribution.

CHARLES.

Have any calculations been made as to the quantity of blood which the body contains, and the celerity of its movement through the heart? Since the whole of the blood of the body passes through the heart, it must, I suppose, repeat its progress very frequently during the day.

DR. A.

It has been considered that the quantity of blood contained in the body, amounts to between 30 and 40 pounds; and that about two ounces pass on from the heart at each pulsation. In this way, at 70 pulsations in a minute, 140 ounces will pass through the heart in a minute, or 9000 ounces in an hour. Hence the whole quantity of blood contained in the body, supposing it to be 35 pounds, will pass through the circulation in about three minutes, or about 20 times in an hour, or 480 times in a day.

HARRIET.

What a continual state of flux and reflux, of ebbing and flowing, takes place in the system; and this, too, when the circulation is not hurried; for I presume that in running, or taking any other violent exercise, the circulation is still more rapid.

DR. A.

Unquestionably; and other phenomena produced in consequence, as increased perspiration, and augmented temperature, which will afterwards come under consideration. — When the contraction of the left ventricle takes place, the blood, as I have already mentioned, is forced into the aorta, or great artery. This consists of two divisions; one of which is termed the aorta ascendens, or ascending aorta, the other, the aorta descendens, or descending aorta; and between them is the curve called the arch, as you would observe in the sketches which I have shown you. From the arch of the aorta, the vessels, as I stated to you, pass off, which supply the head and upper extremities; while the descending aorta transmits vessels which are appropriated to the viscera of the abdomen, and all the neighbouring parts, and which at last terminate in those that supply the lower extremities.

SOPHIA.

Is there any regularity in the disposition and appropriation of these vessels?

DR. A.

There are occasional varieties, but in general there is great regularity in their distribution; so that the anatomist knows where to find a particular vessel, either within any of the cavities, or more superficially; and as they have all of them names, his researches may be conducted with great precision. The names, I may observe, are generally given to the artery from its supposed use, or from the part which it is intended to supply.

An *artery*, as I have already mentioned, is a thick, firm, elastic tube, which, when cut, retracts. It consists of three coats, the external, made of firmly condensed cellular substance, of a white colour, and fixed to contiguous parts; the middle, which has been supposed to consist of muscular fibres, though much difference of opinion has taken place on this subject; and the inner, which is a smooth, thin, dense, and transparent membrane. The thickness of the coats, and their proportion to each other, differ according to the calibre of the artery. In the large arteries, the existence of a muscular coat may be considered as somewhat equivocal; but it is hardly, I think, to be questioned in the smaller. — Both arteries and veins are nourished by blood-vessels, and are also supplied with nerves and absorbents, like other parts of the body. The blood is first forced into the arteries by the powerful action of the left ventricle,

and stream after stream following in quick succession, the column of blood is propelled on to the minutest ramifications. The motion, however, though principally depending on the heart, is promoted by the elasticity of the large, and the muscular power of the small arteries.

SOPHIA.

The quickness of the circulation must, I suppose, be easily affected; for exercise seems to give one a sensation of throbbing all over the body.

DR. A.

Not only does exercise accelerate the circulation, but, with weak people especially, various other circumstances; such as sudden alarm, and many other affections of the mind; the act of digestion; and even a sudden change of posture. The circulation becomes slower as life advances, being with infants as high as 120 or 130 beats in a minute; and gradually falling to 70 or 75, which is about the standard of adult age. The blood is, as I have mentioned, carried over the body by the arteries, and brought back by the veins. The change of the one vessel into the other takes place at the extremity of each, where, from their minuteness, they are termed *capillaries*, or no larger than hairs, though they are still capable of carrying red blood.

SOPHIA.

What do you mean by the term red blood? Is it ever of any other colour?

DR. A.

When blood is taken from a vein, it is fluid; but it soon coagulates, and divides into two parts, the crassamentum, or solid red part, and the serum, or fluid part, which is of a yellowish tinge, and transparent. The crassamentum owes its redness to what are called red particles, which, though very minute, being not more than the $\frac{1}{5000}$th part of an inch in diameter, require vessels of a certain size to admit them. Now some parts of the body, as the white of the eye, are supplied with colourless blood, because the vessels are two small to admit the red particles; but as soon as these vessels become larger from any cause, as from inflammation, then they become apparent, because they are able to admit the red particles, which make them visible.

HARRIET.

But how are you enabled to ascertain this termination of arteries into veins, since they are both of them so exceedingly minute?

DR. A.

If we tie an artery, or press on it, we prevent the blood from flowing on to the extremities, which

shows that its course is thitherward. If we do the same to a vein, we prevent it from carrying on the blood in a reverse direction. On tying up an arm for bleeding, or merely on pressing it tight, we find that the veins enlarge below the compressed part, which shows that the blood is returning to the heart; but a compression of the artery would interrupt the passage of the blood from the arteries to the veins; hence, in bleeding, this is to be avoided. The veins of the extremities, likewise, have valves, which prevent the progress of the blood, except in a direction to the heart.

CHARLES.

Can any sort of fluid be thrown from the arteries into the veins, in order to demonstrate, still more completely, the passage of the blood from the one into the other?

DR. A.

Anatomists have occasionally succeeded in throwing injections from the arteries into the veins; but, in general, the most delicate and subtle injections are unable to pass through the minute vessels which form the extremities of arteries and veins, though they are capable of distending either the one or the other in such a way as to make the white of the eye, or any other part which is usually colourless, quite red, when a red injection is employed.

CHARLES.

We know, by bleeding, that the wounds of veins will heal; but, as you mention that arteries are of an elastic nature, and retract when divided, any injury to them must be of a very formidable nature, and any wound very difficultly healed.

DR. A.

Unquestionably; and hence nature has looked to their safety, by giving them as deep and protected a situation as possible. When they are wounded, or divided, however, they do not heal, but are obliged to be tied up, if large, —that is, a ligature put round them; or, if small, they contract of themselves, so as to resist the passage of the blood through them.

CHARLES.

But then, does not this operation cut off the passage of the blood to the parts beneath, so as to prevent their nourishment, and therefore to occasion their death?

DR. A.

This would be the case, except for a very wise provision of nature, which has effected a general connection of the various arteries, by means of what is called *anastomosis*. In order to understand this, you must consider that arteries send out, in their

course, certain large branches, which are divided into smaller and smaller ones, like the branches of a tree, until they terminate in the most minute. Now according to this structure, it is clear, that if you cut off the communication between the branches and the trunk, you would cut off the supply of the blood. But then the superior branches, which go off from an artery or its subdivisions, send off some branches which unite with others that are transmitted from branches below them. If the artery should, therefore, be divided in an intermediate space, the connection is kept up, between the vessel above and the parts below, by means of these anastomosing, or communicating branches, and thus any inconvenience avoided.

HARRIET.

This is a very beautiful provision of nature; but are not the communicating branches so very minute, as not to be adequate to supply the parts below?

DR. A.

As soon as a large arterial trunk is tied, all pulsation in the parts below ceases; and, in a few hours, the warmth of the part is often a good deal diminished. Nature, however, is not idle under these circumstances: the column of blood, forced from above, and interrupted in its usual progress, is projected into the lateral vessels, and gradually

finds its way through the communicating, or anastomosing ones, which, by degrees, enlarge to a sufficient size to admit of the usual circulation being carried on. Then the heat is restored, and the pulsation returns in the vessels beneath. This is one of the most important provisions in the animal economy, and is that on which the success of so many operations depends; for whenever surgeons operate, they may be always sure, that if they have occasion to tie a vessel, and thus cut off the immediate supply of blood to a part, nature will produce an abundant supply from above. This was a matter formerly in doubt, and therefore surgeons tied vessels with fear and trembling as to the result; but so general is anastomosis, that Sir Astley Cooper, in order to establish its existence, in even the largest vessels, once tied, or, as surgeons term it, took up, the aorta of a dog, and found that anastomosing branches supplied the parts beneath, even after so formidable an operation. — I may just mention to you, that a very scientific operation was devised by Mr. Hunter, from a knowledge of this principle, in a very serious disease, that of popliteal aneurism. This consists in an enlargement of the artery at the ham, which, if suffered to go on, would most likely in time give way, and occasion death. His object was to cut off the supply of blood from it; and for this purpose, he laid bare the artery at the

middle of the thigh, where it is pretty readily accessible, and tied it. He thus cut off the supply of blood to the tumour in the ham, knowing that branches sent off above the tied part, would unite with others below the tumour, and thus supply the leg and foot as well as ever. In this he was not disappointed; and the operation, with some modifications, as that of tying the artery in two places, and dividing in the intermediate space, is one of the most creditable in modern surgery. In both these cases, the extremities of the vessels become glued together, by the effusion of a portion of the coagulable part of the blood, and are soon able to resist the pressure of the column against them.

CHARLES.

You spoke of the blood being carried through the body principally by the action of the heart, but partly, also, by the elasticity, and the muscular power of the arteries. But then in what way does its return take place? for the minute ramifications of the arteries, previous to their termination in veins, would, I should imagine, take away a great deal of the original impulse, and hardly admit of a sufficient quantity remaining for the return of the blood.

DR. A.

As there are continual successive columns of blood sent from the heart along the arteries, these

are necessarily forced into the veins, as the only means of egress; but then, as the blood comes so gradually into the latter, there is no pulsation in them, as in the arteries; and their coats are, moreover, much thinner and more distensible, and want the firmness and elasticity which those of the arteries possess, and to which the pulse is in a great degree owing. It has been thought, likewise, that there is some degree of active force employed by the coats of the vein itself, in passing on the blood, though this is less certain. The motion of the blood in the veins is, however, much more difficultly effected than in the arteries; and hence nature has adopted various devices for the purpose of increasing it. The branches of veins are, together, of greater diameter than the trunks, which is the reverse in the arteries; and hence the blood will flow to the heart in a space gradually becoming narrower, and have its rapidity, therefore, progressively increased. Veins, likewise, have valves in various parts of the body, by means of which any retrogression is avoided, and therefore the ground which has been got maintained: they are more numerous than arteries, and have frequent communications with each other, in every part of their course; and they are so dispersed among the muscles, as to receive a certain propulsion from their action.

CHARLES.

The circumstances which you have now mentioned, relative to the veins, in addition to those which you stated on the mechanism of the heart, seem to make the proofs of the circulation exceedingly conclusive.

DR. A.

The course of the circulation is likewise proved by the transfusion of blood from one animal to another, which has been effected by fixing a tube to the artery of one, and connecting it with the vein of another. In this case, if another vein is opened in the animal which receives the blood, so as to make room for the admission of the fresh blood, an entire change in the mass may be effected.

SOPHIA.

And could this extraordinary operation be performed with safety to the animal?

DR. A.

Many of the early experiments on this subject were unsuccessful; but it has been discovered by modern physiologists, that transfusion can only be practised with safety from one animal to another of the same species. The utility of a process of this kind requires, however, greater experience to ascertain it, than has yet been obtained on the subject.

SOPHIA.

It would appear, then, that this practice might be employed to communicate the exuberant health of one animal to another; though it would rather be at a dear rate, as the animal which parted with its blood, must be as much injured, as the other would be invigorated.

DR. A.

This does not follow; for a healthy animal can part with a good deal of blood without injury.—In great depletion from loss of blood, dogs have been very speedily restored by transfusing into them the blood of other dogs; and one case has occurred in the human subject, in which the injection, by a syringe, of blood from the vein of a healthy person, immediately on its reception into a basin, was attended with considerable temporary advantage.—The microscope has been employed to observe the circulation in particular parts of some animals, which have considerable clearness of skin, as the web of the frog's foot; and I expect that you will be able to witness this interesting phenomenon, by inspecting, in my microscope, the foot of a little prisoner that I have obtained for the purpose. If one of you will hold it, I shall place the web in the field of the microscope; and on adjusting the instrument to your eye, you will observe the circulation distinctly.

HARRIET.

It is very distinct, and rapid, and the globules of the blood are perfectly apparent; but it is difficult to make out the direction in which they move.

DR. A.

A very practised eye is required for observations of this kind.—The circumstances which have been mentioned as favouring the motion of the blood in the veins, have, by many, been regarded as insufficient for the purpose; and some experiments have lately been made, from which it is inferred, that during inspiration, when air is admitted into the lungs, the fluids communicating with its vessels will press into them from the vacuum made by their distension; and hence it is concluded, that the rush which must take place to all parts of the venous system, in order to supply the vacuum in consequence of atmospheric pressure on the surface of the body, must materially tend to support the motion of the venous blood. The same principle is applied to the motion of the chyle in the lymphatic system, in consequence of the connection of the thoracic duct with the vein into which the chyle is poured.

HARRIET.

You mentioned that only the coloured part of the blood returns by the veins: — what becomes of

the part which is without the red globules, or is colourless?

DR. A.

A part of it returns by minuter veins, which refuse entrance except to the colourless portion of the blood; and these soon unite with the larger ones. Another part is carried to various glands, or is otherwise employed, either in affording materials for producing various secretions, or in supporting, or regenerating the different parts of the body; while another is thrown by open-mouthed vessels, either into the various cavities of the body, when moisture is required, or to the surface, to be carried off by perspiration; and you will recollect what I remarked on the subject of secretion, and the action of the absorbents, that a certain balance is kept up between the process which forms, supports, or renews, and that which carries off, so as to preserve the body in a state of health and fitness for its various functions.—The circulation of a nutritive fluid through a heart and blood-vessels, is the mode by which most animals have their vital functions carried on; but there are many varieties in the method by which this operation is accomplished, depending on the peculiar nature of the animal, and the medium which it inhabits.—The blood in most animals possesses the peculiar colour and appearance by which it is usually known; and

such are therefore called *red-blooded animals*, and consist of the mammalia, birds, the amphibia, and fishes; but there are others of a lower description, as the mollusca, insects, and worms, in which the blood is colourless; and such animals are therefore called *white-blooded*. In most of them the circulating system is very obscure, and but little known. The red-blooded animals are divided into the *warm-blooded* and *cold-blooded*, according as their temperature is uniformly much above that of the atmosphere, or as it follows that of the medium in which the animals may live, as air or water. The mammalia and birds are among the first description; for whatever the temperature of the air may be in which they live, their bodies uniformly maintain the same standard. Amphibious animals and fish are among the second. Now we shall find that the respiration of animals has a great deal to do with the production of animal heat, and that, when from any circumstances the respiration is liable to be interrupted, as in the amphibious animals, nature obviates, by a peculiar structure, the necessity for the blood passing through the lungs, as in the mammalia and birds, though at the expence of that production of heat which is so characteristic of the two former classes. This is done by means of what we may call a *single heart*; for the blood, when received from the veins into the auricle and ventricle, instead of passing through the lungs, as

in the breathing and warm-blooded animals, goes off in a vessel which divides into two branches, one of which supplies the body generally, and another is diffused over the lungs, to carry back a certain portion only of that influence, which the lungs are intended to supply.

HARRIET.

Then the completeness of the exposure of the blood to the influence of the lungs, is the great ground of distinction between those animals?

DR. A.

Certainly.

HARRIET.

But there must be a considerable difference between the nature of such animals, since the one set of them can live so much without air, while the other would be suffocated by its interruption for but a very short time.

DR. A.

The difference is considerable; for there is a dulness and want of vigour and vivacity in the cold-blooded animals, which seems to be connected with their conformation, and with the want of the vivifying influence of the air upon them. There is likewise a remarkable tenacity of life, and a power of contraction in their muscles very long after life has ceased, of which I have men-

tioned a remarkable instance in the heart of the frog.

CHARLES.

I have heard of some defects in the circulation through the human heart, which evinced themselves in some peculiar appearances of body.

DR. A.

The heart is subject to many diseases; to increased magnitude; to want of power; to obstruction in the passages from one part to another; to imperfection in the valvular structure, or in the structure of the vessels themselves, all which produce symptoms more or less well marked, and often of a dangerous and alarming description. But there is one imperfection, which is that, perhaps, of which you may have heard, which assimilates the heart to that of the amphibious animals: — it is when there is a communication between the ventricles which allows a part of the blood to escape into the circulation, without passing through the lungs. In this case, the colour of the skin is purple, and the unfortunate person is subject to various distressing symptoms, and has a great defect of general energy. — I may remark, that animals before birth, have a communication between the ventricles, which is necessary on account of their lungs not acting at that time. After birth, when the animal breathes, this com-

munication becomes unnecessary, and closes. It is when it does not close, that the circumstances which I have just mentioned occur.

CHARLES.

You have explained to us very distinctly the peculiarities of the circulation in amphibious animals, which seem to be in a certain degree independent of respiration; but how is it with the other order of cold-blooded animals having red blood, *fishes;* for in them there must be a provision for doing without respiration entirely, since they live wholly in water?

DR. A.

They have not lungs, and they do not live in air; but they dwell in an element which is charged with air, and have an apparatus for availing themselves of it without respiration; for their hearts are single, receiving in their auricle the blood from the veins, passing it on to the ventricle, and the ventricle into the great artery. Then, however, the blood, instead of going on to the general circulation, passes through the *gills*, which are composed of a delicate membrane, very widely expanded, and admitting of a very minute division of vessels over its surface. The blood, in these minute vessels, is exposed to the air contained in the water, and hence has the necessary salutary change produced upon it. It unites in a trunk,

which, like the aorta in the mammalia, carries it into the various parts of the body.

The next subject of our consideration is RESPIRATION, or that particular function which treats of the changes which the blood undergoes in the lungs. This will form the employment of our next meeting; but before I take leave of circulation, it is necessary to notice a singular appropriation which nature has made of some of the veins of the abdomen. Those which bring the blood back from the stomach, the spleen, the sweetbread, the intestines, and omentum, instead of joining the large vein (the vena cava), and transmitting their contents by this channel immediately into the right side of the heart, unite in one trunk, which divides into various ramifications in the liver, and thus imitates in some measure the distribution of an artery. The blood is brought back by veins, which join the vena cava; and thus it goes on to the heart, as it might have been expected to do, from the general analogy of the circulation, without the intermedium of circulation through the liver. The route which the abdominal blood thus takes, is connected with the process of secreting the bile from that organ.

CONVERSATION XVIII.

ON RESPIRATION.

DR. A.

In framing the organs of respiration in the higher orders of animals, nature has had two great objects in view; the one, that of forming the voice; the other, that of completing, as I have already stated to be necessary, the changes which are requisite for adapting the blood to the functions which it is intended to perform in the animal economy.

The organs of respiration, properly so called, consist of the LARYNX, the TRACHEA, OR WINDPIPE, and the LUNGS. The larynx is the projecting part which you can see and feel at the upper part of the throat. It is the commencement of the windpipe, and is the organ in which the voice is formed. The windpipe is the tube which is connected with this, and is divided first into two, and then into smaller branches, called bronchiæ, which at last terminate in small cells, that form the minute structure of the lungs.

CHARLES.

These organs may therefore be considered as nothing more than subservient, or preparatory, to the more immediate functions of respiration.

DR. A.

Nothing more; and they are to a certain degree passive, as is indeed the whole substance of the lungs; but there are other parts which are necessary for carrying on the mechanical process of admitting and ejecting the air from the lungs, and these in man and quadrupeds are principally a very large and strong muscle called the diaphragm, which I have already mentioned to you, as separating the abdomen from the thorax; and various small muscles which lie between the ribs.

SOPHIA.

I do not understand what you mean when you say that the windpipe and lungs are passive organs; they surely are actively employed both in receiving air into them, and in forcing it out.

DR. A.

No more than the barrel of an air-pump is an active organ in working it, or the cylinder of a common pump in elevating the water. When you work a pump, you elevate a piston, which would make a vacuum but for the air or water which

rushes in to supply it. On depressing the piston, you force out the air or water, and thus prepare for a repetition of the process. The lungs accurately fill every unoccupied part of the chest; and it is by diminishing the cavity which contains them, that the air with which they are filled is forced out.

HARRIET.

Is there any particular advantage gained, by not employing muscular contraction in the lungs themselves, to force out the air from them?

DR. A.

In respiration, it is necessary that the blood should be exposed extensively, and in the most divided state possible, to the influence of the air, which renders a secure position necessary, and precludes the firm structure of strong muscles.—The mechanism employed in dilatation and expansion is exceedingly simple; for the contraction of the diaphragm forces down the abdominal viscera, and thus enlarges the cavity of the chest downwards, while the action of the muscles between the ribs raises up the latter, and produces an expansion in another direction. The necessary effect of this increase of size is, that the air rushes in to the windpipe, to supply the void which would otherwise occur; and when the diaphragm and

intercostal muscles cease to act, and become relaxed, the elasticity of the cartilaginous parts of the chest, but more particularly the tendency of the muscles of the abdomen to recover themselves, after being pressed down by the contraction of the diaphragm, have the effect of diminishing the capacity of the chest, and of thus forcing out the air from the lungs, which has been received by inspiration. The alternate dilatation and contraction of the chest which thus takes place, constitutes the act of respiration, which, as I mentioned to you some time since, is of a mixed nature, being partly dependent on the will, and partly independent of it.

HARRIET.

We certainly have the power of regulating our breathing when we exercise sufficient attention; but the necessity of carrying on the alternation seems to be quite incontrollable.

DR. A.

It is fortunate that it is so, for we should be but bad judges of the continual wants of the system; and nature wisely provides for our health, by giving the sense of suffocation to ensure a constant supply of air, and the feelings of hunger and thirst to guarantee to us food and drink. — The *larynx* is made up of a considerable number of cartilages

or gristles united together, forming an irregular sort of tube, open at both ends, and capable, by means of the numerous muscles which it possesses, of those minute varieties of contraction, or enlargement, which are necessary for producing the diversified modulations of sound of which it is capable. It is fixed as a sort of capital on the *windpipe*, which is composed of numerous cartilaginous rings, which are incomplete for about a quarter of an inch at their hinder part. This interval, as well as that which is between the rings, is filled up, partly by transverse and longitudinal muscular fibres, and partly by a firm and ligamentous cellular membrane; and the interior of the whole is covered with a soft mucous lining, which secretes a fluid intended to keep it continually moist. The cartilaginous rings continue for some time after the division of the trachea, but at length disappear in the substance of the lungs.

The LUNGS themselves are of a light, spongy, but tenacious texture, one in each cavity of the chest, capable of swimming in water, separable into subdivisions called lobes, and covered with a membrane called the *pleura*, which doubles back, and lines the cavities of the chest, just as the peritoneum does the cavity of the abdomen. The lungs are very largely supplied with blood-vessels, of which some appear to be destined for the nourish-

ment of the organ; but by far the principal part convey the blood from the right side of the heart, in order that it may, after minute division, and diffusion over the air-cells, be exposed to the influence of the external air, and be carried back to the heart in a proper state for nourishing the body.

CHARLES.

The secretion which you mention as covering the interior of the windpipe is, I suppose, affected during a cold, or any other disease of this passage.

DR. A.

A common cold produces a slight inflammation of the passage, and is attended at first with a diminished secretion; but is carried off by an increase of it, which is a very ordinary mode adopted by nature for removing the inflammation of passages. When the inflammation goes on to a much greater extent, it produces the formidable disease of croup, which is occasionally attended with the formation of a new membrane in the windpipe, from the pouring out of coagulable matter into it, as an effect of severe inflammation. Sometimes the larynx itself is the principal seat of inflammation, and the symptoms are then, as well as in the former case, of the most severe kind.

HARRIET.

Consumption, I presume, is something more than a severe cold; for I have often been surprised to find, that some people recover from severe and frequent colds without much difficulty; and yet others become consumptive, and are carried off at longer or shorter intervals; which makes me think there must be some difference in nature between a cold, however severe it may be, and consumption.

DR. A.

You are quite right; there is an important difference; for colds, however severe, only for the most part excite the tendency to consumption, which already exists in the habit. Consumption consists in an ulceration of a part of the lungs; and this process most generally occurs in a sort of small scrophulous tumors, called tubercles, which may long exist and be harmless; but which, when inflamed by colds, ulcerate, produce a hectic fever, a loss of flesh and strength, and all those symptoms which occur in that serious malady. Sometimes a blood-vessel gives way, and if the wound does not thoroughly heal, an ulcer is produced in consequence; and sometimes an abscess or vomica occurs, from the effect of inflammation, which ends in a similar way.

CHARLES.

The laxity of the substance of the lungs, and their being in continual action, must encourage disease in them very much.

DR. A.

Unquestionably so; for the one facilitates the spreading of disease, while the other prevents the possibility of lying to, for the purpose of waiting for recovery.

CHARLES.

It seems, indeed, extraordinary, that the functions which you mention as being performed by the lungs on the blood, should go on during a severe state of disease in that organ.

DR. A.

They go on less perfectly, as is occasionally indicated by the livid appearance of the lips, countenance, or extremities, and also by the hurry of the circulation; the same quantity of blood having to pass through a less space, than when the lungs are healthy.—But it is time now to give you some account of the particular action which takes place on the blood in the lungs, and to which all the other parts of this function are subservient. The blood which passes from the right side of the heart into the lungs, is, as I have mentioned to you, of a dark or Modena red co-

lour. After circulating through the lungs, it becomes of a florid red, and has then been rendered fit for nutrition, and for the other functions which it is intended by nature to exercise. In this progression through the lungs, it has been freely exposed to the air of the atmosphere, which is continually received and thrown out, by the alternate actions of inspiration and expiration.

HARRIET.

Then it may be supposed that the air of the atmosphere is in some way changed by respiration, since it is by its agency that the nature of the blood is altered in the lungs.

DR. A.

Atmospheric air, as you may recollect, is composed of about 21 parts by measure of oxygen, or the pure respirable part; and 79 parts of azote, or the unrespirable part, with a small portion, not exceeding 2 per cent, of carbonic acid gas. When an animal is confined in a certain quantity of atmospheric air, a part of the oxygen disappears, and an augmented quantity of carbonic acid gas is found to have been produced.

CHARLES.

This, then, I presume, arises from the carbon of the body uniting with the oxygen of the atmospheric air, and forming carbonic acid gas.

DR. A.

Certainly.

CHARLES.

But then is the whole oxygen which the air contains in it, employed in the formation of the carbonic acid gas, which is found to exist in air that has been breathed?

DR. A.

When dark blood is exposed, out of the body, to the action of oxygen gas, it becomes florid; and hence physiologists concluded, that a portion of it was absorbed by the blood, and produced this change. At the same time as it was found, that carbonic acid gas was formed during respiration, it was considered as likely, that a portion of the oxygen was employed in uniting with the carbon of the blood, and thus forming carbonic acid gas, which, you know, is plentifully produced during respiration in crowded assemblies. The process appeared to be therefore a compound one; but some chemists of great accuracy made it exceedingly probable, that the whole of the oxygen which the atmospheric air lost in respiration, was employed in the formation of the carbonic acid gas which was produced during that process.

SOPHIA.

But how is it possible to conduct such experiments with accuracy? Is an animal confined in a certain known portion of air, and the nature of it examined after respiration?

DR. A.

Assuredly. If a small animal, as a guinea-pig, is placed in a proper apparatus, in a certain quantity of atmospheric air, the weight of the air, and its precise nature, may be accurately determined after the experiment.—Now it would appear, from the results of some late experiments of Dr. Edwards that a greater proportion of oxygen disappears, than is necessary to form the carbonic acid generated; and that the original supposition is, therefore, the more correct one; namely, that the disappearance of oxygen is occasioned, in part, from its being employed in the formation of carbonic acid gas, by uniting during respiration with the carbon of the blood; but that it arises in some degree, likewise, from its absorption by the mass of blood, in order to produce further, though unknown effects, in the animal economy.

CHARLES.

In the production of carbonic acid gas in the lungs, is the carbon brought to the lungs in the veins, so as to be ready for uniting with the

oxygen afforded by the air, and thus for immediately forming carbonic acid gas?

DR. A.

This is a point which has occasioned much controversy, and which it is very difficult to ascertain. It was supposed by some, that the veins came to the lungs charged with carbon, in a very divided state; and that this carbon was parted with, when oxygen was received into them by respiration, and thus formed carbonic acid gas in the way which you suggest. But then it has been found, that carbonic acid gas is emitted from the lungs, even if oxygen is not received into them; as in cases where animals have been made to respire some other gases, as hydrogen, when there was no oxygen contained in it.

SOPHIA.

I cannot conceive how experiments of this kind can be made, without the destruction of the animal; or even at all, since the proper function of respiration requires that oxygen should be a part of the air inspired.

DR. A.

Some of the lower animals, as frogs and snails, are less dependent on the immediate supply of pure air to the lungs, than the mammalia and birds; and hence, for a short time, experiments can be made on them, without difficulty or incon-

venience. Kittens, too, for a few minutes after birth, before they have been accustomed to the action of atmospheric air, can respire pure hydrogen; and, in all these cases, carbonic acid gas was found to be produced without the contact of oxygen in the lungs; and it is, therefore, clear, that it must have been extricated from the blood. This circumstance, and some others, render it probable that the oxygen is absorbed by the lungs, and unites in the course of the circulation with carbon, forming carbonic acid gas.—There is a singular circumstance attending the action of the lungs in the production of carbonic acid gas, which is, that the quantity varies, not only in different individuals, but in the same individual at different times of the day, and at different periods of life. The greatest production, 4.1 per cent. Dr. Prout found, is between 11 in the forenoon and one in the afternoon; and the smallest, 3.3 per cent. between half-past eight in the evening and half-past three in the morning; the quantity gradually rising to the highest production, and descending to the lowest. In summer, and in young animals, the quantity of carbonic acid gas formed, is less than in winter, and in the older. There has likewise been found to be a singular difference in the quantity of oxygen which is absorbed at different times, beyond that which is accounted for by the carbonic acid gas formed.

CHARLES.

You have spoken, hitherto, only of the changes which oxygen gas undergoes in respiration. Does the other component part of atmospheric air, the azotic gas, undergo no alteration during this process? Or are we to regard it merely as a diluent for the oxygen?

DR. A.

Experiments on the subject of respiration are of so nice a description, and are liable to so many causes of inaccuracy, that it is not to be wondered, that many difficulties arise in the prosecution of inquiries into its precise nature. It was generally considered that the azote remained unaffected by respiration; but some late observations have shown, that there is sometimes a disappearance, and occasionally even a slight increase in the quantity of azote existing in air after expiration. It seems exceedingly likely, as I remarked on the subject of digestion, that considering the quantity of azote which composes the flesh of animals, and its absence, or paucity, in a considerable portion of the food which they employ, there should be some means of compensating for the want of supply of this important substance by food, in its power of absorption from the atmosphere. There would appear, therefore, to be a power of exhaling, or absorbing azote, according to the exigencies of the system.

HARRIET.

Strangling, and exposure to impure air, operate, I suppose, by cutting off a supply of oxygen from the lungs.

DR. A.

When air is deprived of its oxygen, it ceases to be fit for supporting combustion and animal life; but then there is something positively injurious in the effect of carbonic acid gas, which does not attach to azote; and if the carbonic acid gas produced by respiration, is removed from the air in which an animal is confined, it will live longer than if this were not the case. A fermenting vat, which, you know, is full of carbonic acid gas, produces, almost instantaneously, a deleterious influence on the body, which would very soon terminate in death. Hanging and drowning both operate by withdrawing the necessary supply of atmospheric air, and therefore of oxygen, from the lungs; and the means of resuscitation consist, in a most important degree, in restoring it.

HARRIET.

But is there not, in drowning, a large quantity of water swallowed, which is to be got quit of before the patient has any chance of recovery?

DR. A.

This is only a vulgar idea; and instead of turning an unfortunate person upside down, with a

view that the water supposed to be taken in may be dislodged, we ought sedulously to aim at restoring the circulation, by means of warmth and friction; and the respiration, by means of inflation of the lungs, and imitation of the action of respiration.—The lungs not only require a regular supply of pure air, in order to carry on their functions, but also air of a certain density; and hence, in ascending very high mountains, a great inaptitude for bodily exertion, and incapacity for continuing it long, has been experienced in a very remarkable manner. It is to be remarked, however, that travellers have differed a good deal in the description of their sensations in very elevated regions; and that some do not appear to have suffered more inconvenience, than might be supposed to be produced by the fatigue of such a journey.

CHARLES.

It seems to be very singular, that air should have the power of being taken up by the blood, through the blood-vessels in which it circulates in the lungs; for it does not appear that there can be any actual contact between the air and the blood.

DR. A.

Dr. Priestley found that such is the power of absorption, that if venous blood is exposed to

oxygen contained in a moistened bladder, it would become of a florid red, notwithstanding the intervention of the bladder. Now, in the lungs, the blood-vessels are divided very minutely over the air-cells, which freely receive the air, and communicate with each other; but the coats of these cells are very much thinner than the bladder employed in the experiments which I have now mentioned; and there is, therefore, no difficulty in the transmission of the influence of air through them.

CHARLES.

When we consider the frequency of respiration, and the large dimensions of the chest, the quantity of air necessary for the respiration of a single person must be very considerable. Have any calculations been made upon this subject?

DR. A.

The quantity of air taken in at each inspiration, as well as the amount of what the lungs are capable of containing, are subjects on which physiologists have differed exceedingly. It would appear, however, that about forty cubic inches of air are taken in at an ordinary inspiration; and that the whole lungs, in their ordinary state of expansion after respiration, contain about 330 cubic inches. An eighth part is therefore changed by each respiration; and if we suppose that we

respire sixteen times in a minute, we shall respire, during the twenty-four hours, 921,600 cubic inches, or 591 cubic feet of air.

SOPHIA.

What an immense consumption of oxygen is thus produced. It seems to be very extraordinary, indeed, that considering the prodigious demands on the atmosphere, of the many millions of human beings who inhabit the earth, and of the countless numbers of animals which require a constant supply of air, the oxygen should not be consumed, and the air itself contaminated.

DR. A.

Nature has wisely provided for the removal of what is noxious, from air, and for the supply of what is wholesome. Carbonic acid gas, which animals so copiously produce in respiration, and which likewise originates from fermentation and combustion, is capable of being absorbed by water. It is also, in certain circumstances, taken in by plants, of which it forms a part of the food, so that there is no danger of any deleterious superabundance. Plants, likewise, when exposed to the rays of the sun, exhale oxygen, which seems to arise from the decomposition of the absorbed carbonic acid gas; the carbon forming a part of the substance of the plant, and the oxygen which

had been united with it, being thrown out. From these causes, and from the various decompositions and new combinations which the decay of animal and vegetable bodies, and the formation of new ones, afford; from the immense extent and volume of the atmosphere; the connection which all the parts of it have with each other; and the ready and continual mixture of its different parts by means of winds, and the various currents which heat and cold produce; this immensity of fluid with which the earth is in every direction surrounded, always preserves the same proportion of its component parts, whether in cities, or in the country; on hills or in valleys; at sea, or on land.

HARRIET.

Is it then merely a vulgar error that there is bad and good air? It would be very difficult to convince mankind of this being the case.

DR. A.

I have not said that there is no such thing as good and bad air; or that there is no difference between the air of one place and another. I have only stated that no difference has been found in the proportions of the component parts of atmospheric air, under any variety of position; meaning, of course, to imply, as far as can be ascertained by chemical analysis.

SOPHIA.

But would you take, for examples most strongly opposed to each other, the confined air of a crowded lane, or court, loaded with unpleasant and injurious exhalations, and the fresh breezes of the ocean, diffusing health and cheerfulness on every side?

DR. A.

Certainly, provided you allow a free communication with the atmosphere; for the respiration of many persons in a certain limited space, will make a considerable difference in the state of the air of a room for the time. It is, however, to be remarked, that chemistry can only go a short way in ascertaining very palpable, though minute, differences in the nature of air. Odours, for instance, cannot be detected by chemical means; and the effluvia which emanate from the body, and give rise to various diseases, elude all our endeavours to ascertain their physical nature. When such is the case, there is no wonder that the nice differences between the air of towns, and the country, should only be discoverable by their effects on the human body. These effects are, however, well marked, and well known.—The influence exercised by respiration, in the animal economy, is pretty much the same in all animals; but the mode in which I have described it, principally applies to

man and quadrupeds, in whom the whole plan of the respiratory organs is exceedingly similar. In birds, there are some important modifications; in fish, as I have already mentioned, the air is applied to the blood in the gills, through the medium of the water; in amphibious animals, the principal characteristic is, that the whole of the blood does not circulate through the lungs, and that they can bear the interruption of respiration without injury; but in the insect tribe, and most of the inferior animals, there are various tubes, or tracheæ, which ramify over the body, and open externally by apertures, or stigmata, as they are called, by means of which the air is received and expelled: so that we witness, over the whole creation, an admirable accordance in the modes which nature has thought fit to adopt, for the support of life and health. — I shall now, however, mention to you the principal peculiarities of the function of respiration in birds, which are exceedingly curious. In this class of animals, the lungs are small, flattened, and lie close to the breast; but there is no diaphragm, and there is no alternate expansion and contraction of the lungs, as in the mammalia.

CHARLES.

But how, then, does the air find its way into the chest? For the action of the diaphragm, and the other muscles connected with respiration in the

mammalia tribe, by their expansion, produce a rush of air into the lungs, in order to avoid a vacuum being formed between the lungs and the chest; and by their contraction, force the air out.

DR. A.

In birds, the lungs have several openings, by means of which they communicate with various air-bags or cells, which fill the whole of the cavity of the body from the neck downwards. Now these cells are filled by means of air, which passes into, and out of them, through the lungs, and which, in its passage, produces those changes on the blood circulating through the lungs, which are necessary for the health of the animal.

CHARLES.

But this seems to be rather a complex sort of arrangement. Is there any reason why the same means should not have been adopted in them, as in the mammalia, for effecting the purposes of respiration?

DR. A.

You may recollect, that when I gave you an account of the bones, I mentioned that the bones of birds were hollow, for the purpose of admitting air into them through the lungs, and therefore for diminishing the specific gravity of the animal, and thus adapting it the better for being sustained in

so light a fluid as air. The same purpose is more effectually produced by means of the air-cells which I now mention to you. As these are hollow, and very expansible, shut up at one extremity, and only open to the lungs, it is clear that the animal, on acting with its muscles so as to elevate the breast and ribs, will produce a vacuum in these air-cells, which must be supplied by air which enters from the lungs. A continual and regular supply of air is therefore necessary to supply the wants of the system, as far as the lungs are concerned; but more or less is taken in, just as the animal has a wish to increase or diminish its specific gravity, in order to fit it, not only for walking on the earth, but soaring in the heavens, in all the varieties of density of atmosphere, which a greater or smaller proximity to the earth necessarily occasions.

HARRIET.

What a beautiful combination of office the lungs of birds thus possess; but it is quite clear, from what you have now mentioned, that no size or strength of wing could poise a terrestrial animal in air, unless there were the power of admitting air into the inmost recesses of his body, as happens in birds.

DR. A.

Certainly; and therefore wings are only to be regarded as one of the organs to which birds owe the faculty of flying; for an important part of

this office is owing to the diminished specific gravity, produced by the introduction of air in the way which I have mentioned.

HARRIET.

Then we may regard the body of birds as uniting a movable parachute, with a balloon; but in which the reception, or escape of gas, depend on the will of the animal.

DR. A.

The comparison is not altogether inappropriate; and I may observe, that so careful has nature been, in giving full effect to this structure, that the cells extend even among the muscles of the body, where they are particularly large in the soaring animals, as the eagle, hawk, stork, and lark.

SOPHIA.

I can readily now conceive, how the pouncing of birds from a great height is effected; for the animal has the power, at any instant, of forcibly compressing its whole body, and of thus giving itself a power of descent, which hardly any muscular effect could produce.

DR. A.

Certainly; and in diving birds the same power produces the faculty of sudden descent in the water, which is so necessary to them. The bar-

rels of the quills in birds, too, are hollow, and contain air; and it is said, that it is in some measure owing to the power of diminishing or increasing the contained quantity, that the turkey, bullfinch, &c. are able to produce the quick and voluntary erection of their plumage.—In fish, I have already stated, that the air is applied to the gills through the medium of the water. The gills are covered with a large flap, or operculum, which is made up of arched bones, covered with membrane, and edged with a fringe which can be accurately applied to the part beneath, so as to shut up entirely the slit, or opening into the gills. When the animal breathes, that is, when it wishes water to be applied to the gills, it acts with the muscles of this flap so as to render it convex; this cannot be done, it is clear, without producing a vacuum under the flap; and as the animal is in water, and there is an opening in the mouth which communicates with the gills, the water rushes in among the gills, filling up the space made by the changed form of the flap, and thus applying itself to the minute ramifications of blood-vessels diffused over the gills. When the air contained in this water is no longer equal to its purpose, the water passes away through the air-opening at the edge of the operculum, which the animal has the power of making; and by a repetition of the process, a fresh supply of water is obtained, and the function of respiration kept up.

CHARLES.

Then I suppose boiled, or distilled water, would not answer the purpose of supporting fish.

DR. A.

Unquestionably not; the animal would soon exhibit symptoms of uneasiness, unless the water contained air; and when a small pond is frozen over, the fish would die, by exclusion of air, unless an opening were made to admit a supply of this necessary article. There is, in fish, a part of structure somewhat analogous to the air-cells which I have just mentioned in birds, namely, the *air-bladders* or *swimming-bladders*, which are given to them, as to birds, for the purpose of increasing, or diminishing their buoyancy. These bladders are placed close to the back-bone; they vary in size, shape, and number; and are wanting, or are very small, in such fish as are generally confined to the lowest depths. They form what is called the sound of fish; a part which gourmands prize highly. When the air-bladder is ruptured, the animal loses the power of raising itself, and lies on its back, from the additional weight given to that part of the body, by the removal of the air.

SOPHIA.

But, as fish do not respire in the way of birds, in what manner does the air get into these bladders?

DR. A.

There is a power of forming, or secreting air, which is possessed by the vessels circulating in the membrane which composes them, and which is analogous to what is, in some cases, possessed by other organs, as the stomach.

SOPHIA.

But secretion must be a much slower process of filling the bladder than that employed in birds, when it can be admitted or thrown out at pleasure.

DR. A.

Unquestionably; but the air-bladder is ordinarily full, and is then capable of being acted upon, and compressed, either by the abdominal muscles, or by a muscular structure peculiar to this organ; and thus the air condensed, pursuant to the will of the animal, and an alteration made in the specific gravity accordingly. In some fish there is a communication between this bladder and the stomach, or gullet of the animal, and occasionally an appearance of valvular structure, from which it has been inferred, that the air is capable of being forced out according to exigency. This, however, does not appear very likely; for not only would the process of restoration be necessary, which could hardly be rapid

enough for the demand; but an escape of air in this way has never been observed.

CHARLES.

Has any examination been made into the nature of this air?

DR. A.

Most fish have a peculiar depth of water, at which they usually remain; and it is a curious circumstance, but one which was satisfactorily made out by Biot, that the nature of the air contained in the air-cells, has been found to vary very much, according to the depth which fish generally inhabit. Those which live in shallow water, have azote, with only a very small proportion of oxygen. As the depth increases, so does the oxygen; and after the depth of 150 feet, the average proportion was as much as 70 per cent, while the mean result afforded by fish caught at less depth, was only 29 per cent. Pike, carp, roaches, and perch, which are fresh water, and therefore shallow-water fish, had only from 3 to 5 per cent of oxygen.

CHARLES.

This singular difference would appear to indicate the greater purity of the air contained in deep water, than in that near the surface.

DR. A.

The supposition is a natural one; but so far is this from being the case, that the difference of pu-

rity, it would appear, is rather in favour of the air near the surface.

SOPHIA.

In what way can you collect the air from the air-bladders, so as to make it the subject of experiment?

DR. A.

If the air-bladder be opened under an inverted receiver filled with water, the air will ascend into the receiver and displace the water, just as you have seen it do in the chemical experiments which I have shewn you; and then it becomes the subject of experiment; like any other gas.—There is a curious mode of respiration employed by frogs, toads, chameleons, and some others of the amphibious tribe, which is, that the animal, instead of breathing through its mouth, keeps its mouth shut, receives air through its nose, and by means of the muscles of the jaws forces it into the lungs, from which it is returned, through the nostrils; by the action of the muscles of the abdomen, there being no diaphragm. With this conformation, those animals would be suffocated if their mouths were kept open.

The formation of the VOICE, I have stated to be one of the functions which nature has combined with respiration; and it is very curious, that it is not more than fifty or sixty years since this was the only, or principal use attributed to that function, which, we have seen, possesses so much influence

in the animal economy. I have mentioned the larynx to you, as forming the commencement of the organs of respiration. The opening into this, from above, is called the *glottis*, which is narrow, and of an oblong shape; and there is a little moveable cartilage lying over this opening, as a sort of defence to it, which is known by the name of the *epiglottis*. Now it is by means of the air passing through the glottis, that the voice is formed; for as this admits of various degrees of contraction, it gives to the current of air passing through it from the lungs, as bellows, all the varieties of voice in different animals possessing this structure, and all the different modulations of sound in the same.

SOPHIA.

But is the voice entirely formed in the larynx? I should have thought that the nose and mouth had much to do with it, in as far as we owe our speech to the tongue, and observe a great difference in the tone of the voice, when there is any defect in the mouth or nose, or even in a common cold.

DR. A.

The various cavities of the nose and mouth, give a sort of resonance to the voice, and contribute to its force and clearness; but this is after its formation; and with regard to speech, this takes place by giving different directions to the sound when formed; the opening of the glottis, or the *rima*

glottidis, the chink of the glottis, as it is called, is regulated by ligaments at its sides, which are directed, through the medium of minute muscular structure, by the will, so as to be more or less contracted, and to be made more or less tense, and therefore to be susceptible of vibrations of various frequency, by the passing of the air through the opening. How minute these alterations of tension must be, may readily be imagined, from the easy mode in which the voice produces its numerous and rapid variations of note; and the correct manner in which it effects the various modulations of sound, of which it is capable. This is the more extraordinary, when it is considered, that the curious structure now mentioned, is adapted to a small cleft, not quite an inch long, and not more than two lines broad, which exhibits, to the eye of the most practised dissector, no difference between the apparatus of the most refined voice, and that of the coarsest and least perfect one.

CHARLES.

Then we may consider speech as consisting of two parts; voice or sound, which is formed in the larynx; and the divisions or modifications of sound, which are formed in the mouth.

DR. A.

Certainly. The various modifications of sound depend on the former; speech on the direction

given to the current of air in the mouth, by means of the tongue and lips.

CHARLES.

But I think we possess a power of speaking while we inspire, as well as expire. In this case, there cannot be a formation of the voice, previous to the formation of letters and words.

DR. A.

We can certainly exercise a sort of speech during inspiration, but that is only an inversion of the usual order of proceeding. The same action of the muscles of the glottis will produce sound, whether by means of air taken in or thrown out; and if the air goes to the glottis in a particular direction produced by the lips and tongue, as in the case which you mention, speech will be exercised, though much less perfectly and harmoniously, and much less under the management of the will than in ordinary circumstances.

CHARLES.

I can easily conceive that this must be the case; but in the curious art of ventriloquism, it would appear, that there must be some faculty appended to the ordinary one by which language is formed; for exhibitors in this way, do not seem to use their lips or tongue, or appear to a bystander to

be saying any thing, at the time that they are actively conversing in a feigned tone.

DR. A.

The mode in which ventriloquists perform their feats, is but little known. Some have thought that they really had an accessory organ of speech, or a sort of double or triple larynx, for which, however, there is no sort of evidence; and others, that their operations were to be accounted for by the voice being directed to certain echoing parts of a room, from whence it seemed to originate. But besides that, as you observe, they do not seem to us to employ the ordinary organs of speech, they are capable of exhibiting their powers, in any apartment which may be selected for them. It has been suggested, and with much appearance of probability, that ventriloquism depends on a certain power possessed over the glottis and its membranes, connected, perhaps, with more than ordinary nicety of construction, by means of which power, not only the voice, but words can be formed in them. It certainly seems to be by that organ, that parrots, jackdaws, and some other birds, even linnets and nightingales, imitate human speech; and there is, therefore, a great presumption of the same agency, as far as ventriloquists are concerned.

HARRIET.

There must, however, be a species of finesse

employed by the ventriloquist, in order to give an apparently different direction to his words, from what they really have.

DR. A.

Difference of force will imply difference of distance; and various little circumstances can be readily employed, so as to assist the illusion of the hearer, by withdrawing his attention from the person of the ventriloquist, and making the difference of tone and of force, more easily apply to difference of persons, and difference of distance.

HARRIET.

Is there any known instrument to which we can compare the voice?

DR. A.

It has been considered by some, as most analogous to a wind, and by others, to a stringed instrument; but the most perfect imitation, is that of the vox humana pipe in the organ, in which the sound is produced by the vibrations of an elastic plate, agitated by a current of air, which it continually admits and excludes. In this formation, the vox humana pipe resembles, very much, as far as we can judge, the mechanism employed in the larynx and glottis. Kratzenstein and Kempelen even made some pipes, which imitated very accurately many of the particular sounds of the human voice.

SOPHIA.

There must of course be considerable differences in the form of the larynx and glottis in different animals, from the organ which produces the roaring of the bull or lion, to that which gives us the sweet and diversified melody of the nightingale.

DR. A.

Very little is known concerning the precise mode in which the many varieties of sound are produced; but the examination of the organ of voice in different tribes of animals, exhibits certain variations of appearance, to which we may, without being able precisely to account for them, fairly refer some of the different phenomena of voice. The apparent differences are, however, mostly in magnitude, and cannot, it is obvious, inform us, why some animals neigh or bray, as the horse and ass; why the dog barks; the bull roars; the cat mews or purs; the sheep bleats; or the frog croaks.

The mammalia resemble each other in having the larynx and glottis at the upper part of the windpipe. In birds, there may be said to be two larynxes; one near the mouth, the other just before the division of the windpipe into the branches which enter the lungs. This latter is the glottis, the proper organ of voice; and it is possessed of a great variety of minute muscular structure, so as to admit of every degree of tension and vibra-

tion. The function of the superior larynx seems to be limited to the shutting up, more or less completely, of the upper opening into the trachea, by which means it assists the operations of the lower one. The power which birds have, as I have already noticed, of admitting a large quantity of air into their bodies, affords to them the means of keeping up a much stronger, and more continued current of air through the larynx, than any other animals can do; and gives them, therefore, a volume of voice, which is immensely great, compared with their small dimensions.

SOPHIA.

Is there any reason for supposing any sort of natural language among brutes, for the purpose of their communicating with each other?

DR. A.

I think it exceedingly likely that they have the power of expressing any strong feeling, in a manner which may be sufficiently intelligible to each other; for man can understand some of those natural expressions. But there is an immeasurable distance between such natural and instinctive indications of their wants, and the faculty of speech which man possesses, and to which he owes that most important and dignified enjoyment of life, the power of ready communication between mind and mind.

CONVERSATION XIX.

OF ANIMAL HEAT.

DR. A.

I HAVE already mentioned to you, that there exists, in the animal kingdom, a difference between some of the classes, from the possession of warm or cold blood. This is connected, in a considerable degree, with the varieties which occur in the nature of their respiration; for where the circulation of the whole mass of blood is carried on through the lungs, as in man, most quadrupeds, and birds, the temperature is much higher than it is in the amphibia, fishes, and various other animals, where there are either not lungs, or where the circulation through the lungs is incomplete.

HARRIET.

Is the difference of temperature considerable, then, between the cold and the warm-blooded animals?

DR. A.

Very considerable; for while the cold-blooded

animals generally preserve a temperature of two or three degrees only, above that of the medium which they inhabit; the warm-blooded are not only at a degree of heat which is very seldom reached in the open air, even in the warmer latitudes, but have a power of preserving that heat, under any changes of external temperature which have been known to take place.

HARRIET.

But would the temperature of the cold-blooded animals vary, with every change of temperature in the medium which they inhabit?

DR. A.

Within certain degrees only. For instance, frogs when kept for some time at a temperature of 115° were found to have the heat of their bodies raised only to about 80°.

SOPHIA.

Is the blood of all warm-blooded animals of equal temperature?

DR. A.

The human body has a temperature of about 98°; most quadrupeds of about 100°; while birds are at as much as 107° or 108°; and pigeons are even said to be at 109°. But fish generally, which are cold-blooded, preserve their temperature but little above that of the water in which they are im-

mersed; while the whale tribe, on the other hand, being warm-blooded, preserve, even in the polar seas, where the temperature is always near the freezing point, a heat very little different from that of quadrupeds.

HARRIET.

It is a fortunate circumstance for animals, that, considering the great variety of temperature which occurs in the course of the year, they are able to suit themselves so well to it; but to man, who is so wandering a creature, and who, in his ardour for scientific enquiries, or commercial pursuits, visits every part of the globe, this faculty is of great importance.

DR. A.

Unquestionably; the most sultry heats of the torrid zone, or the greatest cold of the polar regions, may not only be his natural and usual temperature, but may be those which, though a native of a very different region, he may bear with impunity. The heat in South Carolina, at Senegal, and on the banks of the Oronoko, has been as high as 115° in the shade; while in Siberia, in Greenland, and other parts of the high northern latitudes, even Europeans have been able to sustain a cold under which mercury has frozen, which you may recollect does not occur till it is at 40° below zero, or 72° below the freezing point.

CHARLES.

Then it appears, that the human race is not only capable of inhabiting regions, in which the temperature may vary to the extent of 155° (namely 115° added to 40°) but the same individual may bear, with impunity, variations to this extent.

DR. A.

Our adventurous countrymen, under the command of Captain Parry, used frequently to go, in less than half a minute, that is, in the time merely necessary to open two doors, from a temperature of above 60° (which was readily and constantly kept up by means of stoves) to 40° below 0°, and without inconvenience, even though the mouth was not covered; and it was observed by them, that if the weather was calm, they experienced less of the feeling of cold from so great a change, than to one of 0°, if there was considerable wind.

CHARLES.

This we continually observe in this country. But do animals bear these changes of temperature as well as man?

DR. A.

Animals are much more dependent on external circumstances; and their clothing, in time, becomes changed by the difference of climate to which they may be exposed. But so great is the cold which is sometimes experienced in the polar re-

gions, that the white bear, though a native of the climate, finds it beyond his tolerance, and he therefore disappears under the snow, leaving the field to the white fox, which is alone able to bear the severity of the weather.

CHARLES.

The power which man possesses of protecting himself by warm clothing, gives him an immense superiority over every other animal, and is, of course, one of the means by which he is able to bear such varieties of climates.

DR. A.

Certainly; for the effect of cold air on unprotected parts of the body, is very soon to deprive them of vitality; and if proper means are not immediately taken to restore it, (of which a very important one is friction by snow,) mortification might be the consequence.—There were some very curious experiments made, many years ago, by Dr. Fordyce and Sir Charles Blagden, and subsequently by Drs. Delaroche and Berger, as to the extent to which the human body is able to bear great artificial elevations of temperature. They got small rooms heated, partly by flues, and partly by throwing boiling water upon them, so as to raise the thermometer to 240°; and they were able to bear this temperature, with a slight clothing only, without material inconvenience; and could have even borne a higher degree of heat.

SOPHIA.

But this is a temperature considerably above the boiling point of water.

DR. A.

So it certainly is; and yet the body could bear it with impunity. The touch of watch-chains, or any thing metallic, could not be borne for an instant; but at the same time that substances exposed to this great heat, acquired an increase of temperature, more or less rapidly, according to their nature, the body itself felt quite cold to the touch, and had but little elevation above the usual temperature. There was also this curious circumstance attending the experiment, that when the air was set in motion by bellows, it increased much the feeling of heat.

CHARLES.

This was, I suppose, upon the same principle, though conversely, as the sensation of cold, which is in ordinary circumstances produced during a wind. In the latter case, the heated air surrounding the body is carried off as soon as accumulated; while, in the former, the air which is cooled by its contiguity to the body, is carried off, and gives place to a fresh supply of heated air.

DR. A.

Certainly; and in the same way the siroccos,

and other currents of air which are heated above the temperature of the human body, will appear to the human body as the air of a furnace. The sirocco, I may observe, is mentioned by Brydone, as sometimes indicating a temperature of 112°.

SOPHIA.

Were any animals exposed to this high temperature in the experiments mentioned by you?

DR. A.

A dog was kept half an hour in a basket, in a temperature of 236°; he soon began to pant, and hold out his tongue; but he was so little affected, during the whole time, as to show signs of pleasure when they approached him: he was quite lively when liberated, and did not seem at all the worse for the experiment.

SOPHIA.

But in what way can this extraordinary want of power of such elevated temperature in affecting the body, be accounted for? In some circumstances heat becomes latent, but one does not see how this can happen in the present case.

DR. A.

In the first experiments, it was supposed that no elevation of temperature takes place in man, or other animals, by exposure to heated air, in the way mentioned. This, however, was subsequently

found to be not perfectly accurate. An elevation of several degrees, sometimes takes place under such circumstances; but this is still trifling when compared to the temperature withstood.—It was found, that on the first exposure, there was a great sensation of burning, which was, however, speedily relieved by an abundant perspiration, which, by its cooling operation, carried off the heat which might otherwise have produced more sensible effects on the body. So that you are so far right as to a certain quantity of the heat, to which the body was exposed, becoming latent, and thus losing the power of exhibiting itself in the usual way. In the dog, the same effect was produced by transpiration from the lungs, which, in that genus answers the purpose of exhalation from the skin.

CHARLES.

But is it certain that the appearance of great perspiration might not be deceptious, while it was really a deposit on the cooler body, from the vapour with which the room was filled?

DR. A.

A part might arise from this cause; but the agency of the former was indicated, by the effects of confining animals to high temperatures in steam, when evaporation from the surface was prevented. In such cases, the animal suffered

more from the heat, and had its temperature much more raised than in ordinary circumstances. It is to be observed, however, that even a higher temperature than that to which Dr. Fordyce and Sir Charles Blagden were exposed, has been sustained without inconvenience; for Tillet and Duhamel communicated to the academy of sciences, some years previously, an account of some females in the employ of a baker at Rochefoucault, in Angoumois, who were in the habit of going into an oven, heated to the temperature of 278° (105° of R.) remaining there 14 or 15 minutes, and suffering no particular inconvenience, unless they touched the surface of the oven, which, like the metallic substances in the experiments which I mentioned to you, communicated a heat that could not be borne.

HARRIET.

Were any other effects observed in those elevated temperatures, than what you have noticed relative to the bodies of the experimenters, or animals introduced with them?

DR. A.

Eggs were readily cooked, and steaks fried; and the cooking process was hastened, by blowing the warm air on the steak by bellows. Water was not made to boil, unless covered with a little oil or wax, which seemed to prevent evaporation, and in

temperature, however, does not seem much to exceed 120°; but this is an elevation at which heated water can hardly be tolerated; and immersion for three minutes in the Barege water, at 113°, produced much inconvenience. Spirit of wine was insupportably hot to the touch in Fordyce's experiments.

SOPHIA.

Is the heat of the body quite the same, in all temperatures of air, climates, and seasons?

DR. A.

Not exactly; for Dr. Davy found an elevation of one or more degrees of Fahrenheit, in the inhabitants of Ceylon, above that of persons living in northern latitudes. Seasons have likewise a certain influence on temperature, though the subject has been but little attended to. Sparrows were, however, found by Dr. Edwards, to be in February at 105°, in April at 107°, and in July at 110°. The same gentleman also observed, that the power which is possessed by animals, of producing heat, varies with the season; a low artificial temperature reducing the heat of sparrows, much less in winter, than in summer.

CHARLES.

Is it not probable that there may be a greater degree of vigour in the system, in cold, than warm

sleep, and continue totally inactive, until the warmth of the sun rouses them into action, and restores their pristine state of existence. They roll themselves up; become rigid; their respiration being slow, weak, irregular, and for a long time suspended; and their temperature very much diminished. Digestion ceases; they take no food; and the action of their muscular, absorbent, and nervous powers, is for a time suppressed. These animals are called *hybernating*.

HARRIET.

What an extraordinary change; and how remarkable must be the nature of the animals which are subject to such an alteration of appearance. But are there many animals which undergo this extraordinary change?

DR. A.

Not a great number, though there are some in all the classes, except fishes and birds. Among the mammalia, are bats, hedgehogs, dormice, and marmots; in the other classes, are flies, insects, worms, snakes, and oviparous quadrupeds, including under that title, frogs, toads, and lizards.

SOPHIA.

But then it is only in the colder climates, I suppose, that the phenomena of torpidity occur.

DR. A.

In no others; and hence, during the whole year, the insect and snake tribes preserve their noxious qualities in the warmer latitudes.

SOPHIA.

But how is it possible that animals can live without food, and with an almost total suspension of all the functions of life?

DR. A.

It is because the functions of life are suspended; by which means there is not the demand on the constitution, which occurs during active existence; and therefore not the continual waste which requires supply.

CHARLES.

Then I suppose the temperature falls nearly to the degree of the atmosphere?

DR. A.

Within a few degrees of that to which they are exposed; but you will recollect that hybernating animals conceal and bury themselves in situations, where the external air has not its full force. Their temperature, however, always remains some degrees above that of the atmosphere; and it therefore appears, that they have a power of generating

heat, though in a small degree compared to the non-hybernating animals.

HARRIET.

But would exposure to considerable cold during the summer have the same effect?

DR. A.

In many it has been tried; and exposure to freezing mixtures, or confinement in icehouses, have diminished temperature, and produced temporary torpidity.—There is a curious circumstance which attends the exposure of torpid animals to noxious gases, as the carbonic acid, azotic, or hydrogen gases. As they breathe very imperfectly, or not at all, when in this state, they suffer no injury when immersed in them; but as soon as they begin to revive, and to breathe, the destructive agency of these gases is felt. Torpidity, however, exists in various degrees; and hence respiration, and the change effected by it in atmospheric air, are much diversified. The power of taking food likewise varies, being totally interrupted when the torpidity is complete.

CHARLES.

Has the experiment to keep off torpidity by artificial warmth been tried?

DR. A.

In several instances, particularly among marmots, which, in warm rooms, and with a plentiful

supply of food, could be kept in activity during the whole of the winter.

CHARLES.

The effects of heat on the hybernating animals, seem to bear some kind of analogy to what we observe of plants. When the cold approaches, their leaves wither and droop; they soon lose their beauty, and in a considerable degree their external character, which is only restored by the return of spring and of warmth.

DR. A.

You are quite right: heat is indeed one of the most important agents which nature employs in the production of that continual series of changes which are every where exhibited, whether in the animate, or inanimate world; whether in the animal, vegetable, or mineral kingdom. Every body in nature possesses a certain quantity of it, which is, as you know, either in the sensible or latent state, or both; and the sun is the great means by which temperature is kept up, or renewed. The animal body is itself, however, a system in which heat is generated for its own peculiar wants; and in this we see a beautiful provision of nature for the independence of the animal, and for the proper carrying on of its functions, under almost every variety of temperature.

SOPHIA.

I am very anxious to know in what way this continual production of heat is effected. It is a wonderful process.

DR. A.

I shall endeavour to give you a general view of what is known on this subject; but it is one of great difficulty, and many points relative to it require further elucidation. After the modern doctrines on chemistry had thrown a light on the phenomena of combustion, which had not been received before, attempts were made to apply the same principles to account for the production of animal heat.

SOPHIA.

But was it not rather a wild speculation to suppose any analogy to exist between combustion, in which the heat is exceedingly elevated, and animal heat, which rises so short a way in the scale of temperature? unless, indeed, we are to imagine, that there is something of a furnace within us, from which the heat of our bodies is derived.

DR. A.

You hardly, however, recollect the phenomena of combustion, or you would not consider the analogy to be so imperfect.

contact with the lungs. If the oxygen had become fixed, and its gaseous form had disappeared, I could easily conceive that the heat necessary for maintaining it in the state of air would be evolved, just as when vapour becomes water, or water ice; but it was gas before its contact with the lungs, and gas afterwards.

DR. A.

Your objection is a very fair one; and the circumstance depends on that particular principle in chemistry, which is termed *capacity for heat*. This is the particular quality or disposition which bodies possess, by means of which they require different quantities of heat to raise them to the same temperature.

HARRIET.

I recollect that in the Conversations on Chemistry, this principle is exemplified by the different heating of similar weights of three different bodies, lead, chalk, and milk, when placed in an oven. The lead heated first, the chalk next, and the milk most slowly, though they were all exposed to similar temperatures.

SOPHIA.

And it was further exemplified, that these bodies possessed different quantities of heat in them, by the different quantities of heat which they were

the blood is changed from a dark, to a florid red, in the lungs, in consequence of the influence exercised upon it by atmospheric air. It was considered that the capacity of the florid, is greater than that of the dark-coloured blood; and that when the latter became converted into the former, the heat which was elicited from the atmosphere, and would have raised the temperature of the blood in the lungs, was, as it were, absorbed, and its sensible effects suspended.

CHARLES.

So that, in point of fact, though both descriptions of blood would be of the same apparent temperature, yet they would actually possess different quantities of heat.

DR. A.

Certainly.

CHARLES.

But then in what way would heat, according to this idea, be extricated over the body?

DR. A.

By means of the conversion of the florid into the dark-coloured blood; for as this takes place all over the body, wherever arteries terminate in veins, heat would of course be elicited, and in a very gradual and uniform way, merely by the conversion of the arterial into venous blood. This

was a very beautiful and satisfactory view of the subject; and as the difference of the capacity for heat, of arterial and venous blood, was supposed to be as 114.5 to 100, there was difference enough to account for the effect produced; but, unluckily for this theory, it has since been discovered by Dr. Davy, that the difference of capacity, between the one and the other, is so small, as not to be sufficient to account for the phenomenon in question.

HARRIET.

How very perverse it is, that when a theory has been discovered, which accounts satisfactorily for every difficulty in a subject, we should all at once have our views unsettled, and be turned adrift into the world of doubt and uncertainty.

DR. A.

It is doubtless a hard case, though not an unfrequent one; but these are disappointments which must be borne with fortitude by all who have truth for their object.—There is another objection, however, which is not less unmerciful on the chemical theory of animal heat, than that which I have now mentioned: it is this, — that after an animal has been decapitated, the circulation of the blood through the heart and lungs can be kept up, and the change of its colour from venous to arterial, produced, without any production of animal heat.

This, therefore, evinces that there are many obscurities in the subject, which have not been yet removed.

HARRIET.

But in such cases, were the changes produced on the air respired, just as in ordinary respiration?

DR. A.

They were very similar; carbonic gas was formed, and oxygen disappeared.

HARRIET.

Then it would appear, from this extraordinary and repulsive experiment, that respiration is in no way connected with the production of animal heat, since the air exerts its proper influence on the blood, and no heat is produced.

DR. A.

And yet we cannot at once reach this conclusion; for the animals which have the most perfect system of respiratory organs, have most heat; and in them it is uniformly observed, that whatever quickens the circulation through the lungs, will augment temperature; and whatever retards the circulation, will diminish it. This, therefore, evinces a connection between those functions, which is not yet thoroughly understood. I may observe, however, that some later experiments, made both in

France and in this country, show that Mr. Brodie's experiments (for it is to that able physiologist that we are indebted for them) are not so irreconcilable, as was originally imagined, to the chemical theory of respiration. It is to be remarked likewise, that when carbonic acid is formed out of the body, by the combustion of carbon in oxygen, (which is a process similar to what occurs in the lungs,) there is found to be an elicitment of a very large quantity of heat, which, it is reasonable to suppose, would be disposed of in heating the body, where the same phenomenon goes on within it.

CONVERSATION XX.

GROWTH AND DECAY.

DR. A.

In the general views which I have endeavoured to communicate to you, relative to the animal economy, I have treated of those functions, which tend to the support of life and strength, and which are connected with the exercise of the particular powers and properties, for which the animal is destined. We have got nearly to the termination of the plan, which I meant to pursue for your amusement and instruction, in our late meetings; and it is my intention, on the present occasion, to give you some information relative to the growth and decay of the body, as a finále to our operations respecting the animal economy for the present.

The whole of the organs of the animal body are intended as a mutual support and protection to each other. Nourishment goes on at all periods of life, but in very different degrees. In infancy and youth, it is intended that the various parts of

the body should expand to their designed size; and the food which is taken in, is therefore not only destined to support, but to enlarge. Growth, however, is limited by that law which nature has attached to every object in the creation; and after maturity has been obtained, the principle of decay, which is inherent in our natures, soon becomes manifest. The apparatus which is attached to life, is to last but for a certain time, in spite of the admirable provisions which exist for preserving health, and for warding off disease. — At the earliest periods of existence, growth is exceedingly rapid, and nature seems to be solely occupied in contributing to it. The alternations of food and rest, occupy nearly the whole time; and it is not till a certain portion of size and strength are obtained, that other objects can be attended to. This is, however, principally the case with man; for in many parts of the animal creation, the young soon obtain a certain independence of their parents.

HARRIET.

The recruit which is obtained by sleep, appears to be a very wonderful provision of nature, for restoring the energy of the frame.

DR. A.

A very extraordinary and admirable one, in which, during an oblivion of every external cir-

cumstance, the body obtains a revival of its powers, and the capacity of resuming its exertions. Mere quiescence is not sufficient to restore the animal strength after fatigue. That can go only a certain way; but in the effects of the balmy influence which sleep exercises, the mental and bodily faculties obtain a sure, and constant renewal of their energies.

CHARLES.

We are, I presume, to take sleep as a fact, which is not to be accounted for, any more than the operations of mind, or the connection which the mental and bodily part of our frames have together.

DR. A.

Some endeavours have been made, on mechanical principles, to account for this phenomenon, but they have been quite insufficient; and we must be satisfied on this, as well as various other subjects of an obscure nature in physiology, to attend to facts, and not to burthen ourselves with useless, and unavailing hypotheses.—The soundest sleep is enjoyed during complete recumbence, when there is a total cessation of all voluntary exertion. Sleep is, however, occasionally to be obtained, in great fatigue, under almost any circumstances. It has been said, that during the battle of the Nile, some of the boys were so overpowered with

fatigue, that they lay down and slept most heavily, amid the hottest of the action. Couriers and postillions have often been known to sleep when on horseback; and it has been stated that many of the soldiers of General Moore's army fell asleep during their march, and continued walking on, notwithstanding this occurrence.

SOPHIA.

It seems to be hardly credible, that persons should be able to sleep without falling.

DR. A.

And yet we know that there is such a thing as somnambulism, or walking in sleep; which, though not quite a case in point, shows clearly, that under particular circumstances, a certain command may be retained over the limbs during sleep. Perhaps the greatest privation to which the body can be subject, is want of rest; and the utmost refinement of punishment which can be inflicted, is that of continually interrupting and preventing sleep, as we read has been done by some tyrants of old. Captain Barclay's exertion of walking 1000 miles in 1000 hours, was a very great one, merely viewed as being 24 miles a day, for above 40 days. It was, I imagine, more than any horse could go through; but when you consider that it was two miles every two hours, so as that never

more than one hour and a half's sleep at a time could be obtained, it is quite extraordinary how he could accomplish such an enterprise.

SOPHIA.

I am afraid it is a tender subject to touch upon with us; but I should like to know what quantity of sleep may be considered to be necessary in the 24 hours?

DR. A.

Much depends on habit, and something on original constitution: but few people can do without six or seven hours' sleep, and none ought to have more than eight or nine. Laborious students, however, and others who are very provident of their time, have limited their sleep to four or five hours, or even less.—During sleep, there is a gradual diminution of animal action. The pulse becomes slower; the process of digestion goes on less vigorously; and there is a slight approach to that sort of suspension of action, which occurs in the hybernating animals. The diminution of heat which occurs during sleep, is well marked by the circumstance, that if persons fall asleep with only their usual clothing, they often find themselves exceedingly chilly on awaking.

SOPHIA.

When people dream, is it from their sleeping less sound, and from the powers of the mind being

therefore less completely suspended, than in ordinary circumstances?

DR. A.

This is not unlikely; because we generally find, that a first sleep is more sound, and is freer from dreams, than a second, or what occurs nearer the time of rising.

HARRIET.

What a very extraordinary thing dreaming seems to be. It appears as if some of our faculties were as acute, or even acuter, than ordinary, while others are totally suspended.

DR. A.

We certainly feel ourselves able to perform, with perfect facility, all the ordinary actions of life, but have a most extraordinary want of recollection of past events; so that we can act with persons who have been long dead, and with a total oblivion of events and circumstances long gone by. It is likewise curious, that, though we may seem to possess our usual judgment, and power of observation, in many things, our dreams often exhibit a great wildness and inconsistency, which pass by without offending us, or appearing to be at all extraordinary.

CHARLES.

We seem to go on, from subject to subject, in a

very desultory way, and as though we had no command of our thoughts; and I suppose that various circumstances which have recently taken place in waking hours, may make our ideas take a particular direction.

DR. A.

This is unquestionably the case; and it seems as if, when once a particular direction was given to our ideas, our imagination went on in a most uncontrolled way, and seemed to be on the watch for new trains of association, and for new and often grotesque and fanciful combinations. The effects of various diseases, particularly indigestion, and some of those which affect the chest, in producing unpleasant dreams, are well known; and every one has occasionally felt, that a late and heavy meal, will give rise to various unpleasant dreams, and go to the extent of producing nightmare. I heard the late Professor Gregory, when I attended his lectures many years ago in Edinburgh, give a curious example of the effect of a bodily impression in producing a dream. He was at Rome, and being ill of fever, sinapisms, or mustard poultices, were applied to his feet: these, when they began to take effect, produced a considerable heat in those parts, and made him dream that he was ascending Mount Ætna, and that he found the heat of the ground insupportably great.—It is

the readiness with which dreams follow certain trains of association, and the want of any apparent control over them, that led Mr. Dugald Stewart, in investigating the state of mind during sleep, and in considering what faculties continue, and what are suspended at that time, to form the opinion, that during sleep, those operations of the mind are suspended, which depend upon the will; the succession of thoughts following the usual laws of association, without having that sort of influence exercised upon them, of which we are capable, when awake.

CHARLES.

So that memory and judgment, Mr. Stewart supposes, are suspended, because their exercise requires a certain voluntary exertion on our part; and, hence, we neither compare the circumstances which seem to be passing before our eyes, with past events, nor discover their extravagance or inconsistency.

DR. A.

Such is his opinion; and a part of his theory depends on the supposition, that trains of ideas are continually passing through the mind, both in sleeping and waking; or, in other words, that we always dream during sleep, but do not always recollect our dreams.—In the period of infancy, a larger portion of sleep is necessary than in after life.

The same is the case in old age, when nature is soon exhausted, and seems, with the occasional loss of faculties, to go back to the feebleness of early life.

CHARLES.

There must, I should imagine, be great original differences in the strength of individuals, as indicated by the various periods at which old age exhibits itself.

DR. A.

I have no doubt that there are such differences, independently of the effects produced by various habits of life. It is very seldom, however, that old age is allowed to make its quiet and imperceptible inroads. The numerous accidents to which we are subject, and the various causes of disease which are continually in operation, leave but few to die of old age. The earlier that the human species advances to maturity, the sooner is the approach of age; and, in some curious examples, where maturity occurred during infancy, the decline of life came on at little more than the usual adult period. In southern climates, likewise, where maturity is early, age comes on rapidly.

HARRIET.

Is there any reason for supposing, that there is much difference between the modern period of life, and that of ancient times?

DR. A.

David speaks of the age of man being, in his time, only threescore years and ten, or in very rare cases, fourscore years, which is what we may regard as the general limit of human existence at present; nor does it appear that the ancients, at all exceeded the average length of life in modern times. Of course, we set aside that extraordinary duration of existence, which is described in the early part of the Mosaic history, and was destined to afford a better opportunity for peopling the earth.

CHARLES.

I think the famous Parr lived to the age of 152 years, and Jenkins to 169. It would be curious to know whether their families were at all distinguished for longevity.

DR. A.

It has been said that Parr's was; and it is not unlikely that the stamina, which persons who live to advanced periods, possess, may be capable of transmission. Parr's grandson, Michael Michaelstone, lived to the age of 127, and died in the year 1763.—There was a curious statement made out some years since, relative to the ages of the resident pensioners of Greenwich Hospital, amounting at the time to 2410 in number, from which I shall point out the principal particulars. Of this num-

ber, 96 had attained to, or passed the age of 80; one only was above 100; 15 were 90 or more; and 80, were 80 or more. About 42 of the 96 were of aged families; and in some of this number, both parents had been aged. 80 of the 96 had been married; 79 were in the habit of using tobacco in some form or other; and 48 had drunk freely. 20 were entirely without teeth; 52 had bad, and 14 good teeth. But the oldest man in the house, who was 102, had four new front teeth within the five preceding years. Vision was impaired in about one half; and hearing, only in about a fifth part of the number.

SOPHIA.

How pleasantly Greenwich pensioners must live, amid a total freedom from care, and with nothing to do but to enjoy themselves among many of their old cronies; fighting over again their battles, and snugly comparing their adventures, and talking about their hair-breadth escapes.

DR. A.

Yet it is not amid the greatest apparent aptitude for enjoyment, that the human mind usually possesses most pleasure; and I fear that their total want of care, the monotony of their lives, and the absence of regular employment, may sometimes make their time hang a little heavy upon their hands. Greenwich Hospital is,

however, a noble asylum, worthy of a great nation to support; and nothing is a more agreeable sight, than that of a veteran, who, after having served his country with honour, gratefully reposes on its bounty; and, with such an interest in passing events, as binds him reasonably to this world, makes a prime object in preparing for the next.

HARRIET.

Does longevity, as far as you know, occur most in the higher, or the lower orders of society?

DR. A.

I should say most in the lower; for the higher, and even middle classes, are subject to various causes of indisposition, which do not attach to those who are much below them. Old Parr, and Jenkins, both of them lived, from necessity, on the coarsest fare. The former married when at the age of 120; and when at 130, was able to thrash, and to do any description of farmer's work. He was brought from the pure air, and homely diet of the country, into the family of the Earl of Arundel, in London, where he drank wine and lived luxuriously; and he was, in consequence of such a change in his mode of living, speedily carried off.

Many of the instances of longevity have occurred in workhouses, where, though there is generally a sufficiency of the plainest food, there are

no luxuries; and the plain diet, and invigorating employments of a country life, are certainly more favourable to health, than the close air, and refinements of towns; though it is not to be forgotten, that the country labourer, who is exposed to all weathers, is exceedingly liable to the complaints which arise from cold and damp.

CHARLES.

It must likewise be borne in mind, in any calculation of the proportional mortality of the higher and lower orders, that as the latter are so much more numerous than the former, one case of longevity, in the higher orders of society, counterbalances several in the lower.

DR. A.

This must certainly be the case; and it is a circumstance which does not seem to have been sufficiently attended to. — It has been said that there have been greater examples of longevity in Great Britain, than any other country of Europe; and a curious circumstance is mentioned by Sir William Temple, on the authority of Philip de Comines, that none of the kings of France lived to threescore, from the time of Charlemagne to that of Louis the Eleventh; whereas, in England, from the Conquest, to the end of Queen Elizabeth's reign, (which is a much shorter period) there

have reigned five kings, and one queen, whereof two lived 65 years, two 68, and two reached at least the 70th year of their age. Sir William Temple likewise states, that he was informed by M. Pompone, the French ambassador at the Hague, where Sir William was ambassador from England, that he had never heard of any man in France who had arrived at 100 years. — It is very clear, however, that, notwithstanding the variation which there may be in the longevity of the human race, in different countries or districts; and in spite of the continual complaints which are made of the shortness of life, man is a long-lived animal. He is exceeded, in length of years, by but a very few of the other inhabitants of the globe.

SOPHIA.

Very long life is hardly desirable, since it must leave a person very much alone in the world; and diminish the value of existence, by the want of sympathy with those around us, on which so much of the comfort of life depends.

DR. A.

And yet life always possesses certain attractions; and few have such a position of feeling, as to be willing to give up animal existence, without a struggle for its preservation. The human mind gradually reconciles itself to new circumstances;

and frequently possesses, even in the most desolate, and adverse state of things, certain sources of enjoyment, into which it is difficult to enter.

HARRIET.

But the wreck of mind is the most humiliating to our nature; and I hardly know any thing more painful than the second childhood to which some are reduced.

DR. A.

It is a serious lesson on the evanescent nature of sublunary things, that not only our corporeal strength, but the proud exercise of those faculties, which place man so much above every other animal in the creation, are of very short duration. The most powerful monarch, the most distinguished philosopher, poet, and statesman, are equally destined, in a few years, to sink into dust; and, before the close of life, frequently to exhibit, with the loss of their bodily vigour, a diminution, or disappearance of those powers of intellect, which governed, instructed, or delighted mankind.

HARRIET.

Is there any reason for supposing that the ancients exceeded the moderns in height?

DR. A.

The magnitude of ordinary men does not appear to have been greater, at those periods, when so

much depended on personal prowess, than in modern times, when, by the changes introduced into the mode of warfare, the powers of different individuals are so much equalised. There are differences, within certain bounds, in the size both of nations and individuals; and instances sometimes occur of monstrosities, both in largeness, and smallness of dimension. Giants have been mentioned, of from seven feet to nine feet in height, and sometimes much more; though this last seems to be the utmost limit of stature for which there is tolerable evidence. Dwarfs, on the other hand, have occurred, of from 40 inches, to about 16 inches in height. But in all these deviations from usual size, there is generally something irregular and anomalous in structure and appearance; and Nature seems to have reserved her greatest beauty, symmetry, and activity, within certain moderate limits.

CHARLES.

The bulk of man depends, I suppose, in some degree, upon his mode of living; but I have often been surprised at the difference which occurs between men and brutes, as to the power of augmenting their size. A farmer may pretty securely depend on fattening an ox or a sheep on a good pasture; but some people are lean and lank under plentiful diet; and others seem to get large on a moderate, or even a small quantity of food.

DR. A.

The more removed mankind are from a state of nature, the more dependent they seem to be on accidental circumstances. In the savage state, probably, a man might be as certainly fattened as an ox; and we learn that during the sugar season in the West Indies, the negroes always become plump. Even with us, butchers and innkeepers are very often large; for they live well, and have just enough exercise to preserve them in health. But a soldier, a sailor, and a postillion, though they have plenty of good food, are prevented by their respective professions from carrying much flesh. There have been many examples of persons who have become very large, gross, and diseased, by indulgence; and who, by a material alteration in their mode of life, have reduced themselves to moderate dimensions, and have recovered their health; and one has occasionally heard of some calculating gourmands, who, after certain periods of enjoyment in all the luxuries of the table, have starved themselves for a time, in order to resume their sensuality with less risk.—A curious example of the good effects of temperance, in recovering and preserving health, occurred in the famous Lewis Cornaro, a noble Venetian, who was originally of a feeble constitution, and by irregular indulgences, brought himself, at the age of 40, to the brink of the grave. He adopted a rigid

course of temperance and sobriety, on being told that this was the only chance he had for his life; and he lived to above 100, going off like one in a sleep. He allowed himself not more than 12 ounces of food, and 14 ounces of drink, in the day; and when he was above the age of 70, the experiment of adding two ounces to each, by the advice of his friends, had nearly proved fatal to him. The food that he employed was nutritive, and his drink small wine. — But one of the most extraordinary instances recorded, of the restoration of health, and reduction of size, by temperance, was in Thomas Wood, the miller, of Billericay, in Essex, who, under full living, became very corpulent about the age of 40; and at 44, had many threatenings of apoplexy, and other serious maladies. On reading the life of Cornaro, he altered his mode of living, so as gradually, but in no long time, to reduce himself 10 or 11 stone. He entirely recovered his health and strength; and died of an inflammation of his bowels, brought on by cold, at the age of 64. The daily nutriment which he found perfectly adequate to his comfortable support, consisted of a pound of the flour of which the best kind of sea biscuit is made, boiled into a pudding, with a pint and a half of skimmed milk. He used a great deal of exercise, and took about five hours' sleep. At one time, when he took three pints of skimmed milk,

and two eggs, with his pudding, he thought he got fat, and therefore made a reduction to what I now mention, which became his usual daily nutriment. I have talked with Mr. Wood's son, who occupies the house in which his father resided, on the subject of his father's singular history; and have seen two or three manuscript volumes of correspondence, mentioned by Sir George Baker in the account which he published of the case, and to which the success of this curious discipline gave rise. One of Mr. Wood's imitators, it is said, having, from faith in the efficacy of the pudding, had it made with every regard to punctilious accuracy, long persevered sedulously in its use. You will not, however, be surprised at the difference of effect, when I tell you, that he took it in addition to, and not in the place of, his ordinary luxurious repast.

CHARLES.

We have an example, in the reduction of weight in jockeys, of the effect of spare diet and exercise on the human frame. Are you acquainted with the mode pursued by them in accomplishing their object?

DR. A.

In general, when feats of strength and activity are to be performed, either by men or animals, a certain *training* is employed, by which they are

brought to the best possible state of health and strength, both in wind and limb. This was done with the ancient athletæ, and is practised likewise now-a-days, in fitting men for boxing, or for running matches; horses for racing, and cocks for fighting. But the jockey has a totally reverse plan pursued with him; and being obliged sometimes to reduce himself to a very low weight, in a very short time, he can only do so by starvation, exercise, and profuse sweating. It is said, that he can effect the object of a reduction of a stone and half, or even more, in as short a time as a week or ten days. He eats very sparingly; takes wine and water for his drink; walks daily 15 or 16 miles, with five or six waistcoats or more on him, two coats, and as many pairs of breeches, by which means he is made to perspire very profusely; and takes a good deal of rest. In the instance of John Arnall, when rider to his present majesty, then prince of Wales, who was desired to reduce himself as much as possible, in order to ride some favourite horse, no animal, or even farinaceous food, was taken for eight succeeding days; but only a piece of apple occasionally. He was not injured by this discipline; and it appears, that when jockeys resume their ordinary mode of living, they very speedily recover their flesh, though they are seldom, at any time, more than nine stone in weight. You thus see what a singular power the animal frame possesses, of

accommodating itself to a great variety of circumstances. This is wisely and bountifully intended, without doubt, to increase the sphere of our gratifications and usefulness; though it is often perverted to mean and ignoble purposes.

But after all the exertions of the best regulated, and the most useful life; after nature has availed herself of her numerous resources to preserve health, and to keep off disease; after all those curious compensations and adaptations which the study of our frame lays open, have been called into repeated operation; there is, most surely and inevitably, whether at the usual period of old age, or at that more extended limit of existence, which a very few only are destined to attain, a failure of the powers connected with life. The bodily organs are unable to carry on their functions; they become inanimate matter; are decomposed into their original elements; revive again in new shapes, in plants and animals; and in this way, assist in the continuance of those series of existences, which were commenced by the fiat of the Deity, and are continued by the laws to which he has given origin.

The principle of life is wholly unknown to us. We cannot detect, by the nicest powers of human discrimination, the circumstances on which depend the difference between a living body, in the fulness of health and beauty, where an ample and interesting series of active operations is uninter-

ruptedly, and to all appearance spontaneously, going on; and the same body, a mass of lifeless matter, subject alone to the laws which inanimate substances are made to obey. But if the nature of vitality, of that principle which is common to the whole animal, and in some measure to the vegetable kingdom, is concealed from us by an impenetrable veil, still more is that of the sublime and immortal part of our constitution, which approximates man to the Author of his existence, and fits him for contemplating the wisdom, the beauty, and the harmony of those operations, which are continually going on around him.

CUVIER'S DIVISION

OF

THE ANIMAL KINGDOM.*

DIVISION I. VERTEBRATED ANIMALS, or those having a vertebral column or back bone.
DIVISION II. MOLLUSCA, animals of soft texture.
DIVISION III. ARTICULATED, or jointed animals.
DIVISION IV. ZOOPHYTES, animal plants, or radiated animals.

DIVISION I. VERTEBRATED ANIMALS. Four Classes.

CLASS I. MAMMALIA, animals which give suck.

Order i. Bimana, or two-handed; man only.
Order ii. Quadrumana, or four-handed; monkeys of all kinds.
Order iii. Carnassiers, or flesh-eating.

Subdivision i. Cheiroptera; winged-hands; as the bat.
Subdivision ii. Insectivora; living on insects; as the hedge-hog, shrew-mouse, and mole.

* Referred to in vol. i. p. 47.

SUBDIVISION III. CARNIVORA; carnivorous.

A. *Plantigrade;* which walk on the soles of the feet; as the bear, racoon, badger, and glutton.

B. *Digitigrade;* which walk on the toes; as

(a) Weasels.
(b) The dog kind; domestic-dog, wolf, fox.
(c) Civet-cat.
(d) Hyena.
(e) The cat-kind; lion, tiger, leopard, panther, lynx, common-cat.

C. *Some of the amphibious;* as seals and walruses.

D. *Marsupial* or *pouched animals;* as kangaroos and opossums.

ORDER IV. RONGEURS, rodentia, or gnawers; as castors, beavers, rats, mice, marmots, squirrels, porcupines, hares, rabbits, guinea-pigs.

ORDER V. EDENTÉS, edentata, or toothless; as the sloth, armadillo, pangolin, ornithorynchus.

ORDER VI. PACHYDERMATA, or thick-skinned; as the elephant, hippopotamus, pig, rhinoceros, horse, ass, zebra, quagga.

ORDER VII. RUMINANT; as the deer, antelope, goat, sheep, cow, buffalo.

ORDER VIII. CETACEA, the whale-tribe.

CLASS II. BIRDS.

ORDER I. BIRDS OF PREY.

SUBDIVISION I. DIURNAL; as the vulture, falcon, eagle, hawk.

SUBDIVISION II. NOCTURNAL; as the owl.

ORDER II. PASSEREAUX, or the sparrow tribe; as the magpie, swallow, thrush, sparrow, crow, wren.

ORDER III. GRIMPEURS, or climbers; as the woodpecker, cuckoo, toucan, parrot.

ORDER IV. GALLINACÉS; the gallinaceous or poultry-tribe; as the peacock, turkey, pheasant, barn-door fowl, partridge, pigeon.

ORDER V. ECHASSIERS, the stilted or waders; as the ostrich, cassowary, plover, crane, heron, stork.

ORDER VI. PALMIPÈDES, or web-footed; as the pelican, duck, swan, and goose.

CLASS III. REPTILES.

ORDER I. CHÉLONIENS, or tortoises.

ORDER II. SAURIENS, the lizard tribe; as the crocodile, lizard, gecko, and chamelion.

ORDER III. OPHIDIENS, the serpent tribe; including the boa constrictor, and such serpents as are not venomous, as well as the venomous serpents.

ORDER IV. BATRICIENS, the frog tribe; including frogs, toads, salamanders, the proteus, and syren.

CLASS IV. FISHES.

SERIES I. CHONDROPTÉRYGIENS, or the cartilaginous; as the lamprey, shark, skate, thornback, sturgeon.

SERIES II. OSSEUX, the bony, whose divisions are principally taken from the gills, jaws, or fins; and are

Order I. *The Plectognathes*; as the sun-fish, trunk-fish.

Order II. *The Lophobranches*; as the pipe-fish, and pegasus.

Order III. *The Malacopterygiens;* as the salmon, herring, sein-fish, pike, carp, loche, silurus; cod, turbot, sole, remora, eel.

Order IV. *The Acanthopterygiens;* as the perch, mackerel, dolphin.

DIVISION II. MOLLUSCA.

Six Classes, principally constituted from the organs, and mode of progression.

CLASS I. *THE CEPHALOPODES;* as the cuttle-fish, and nautilus.

CLASS II. *THE PTÉROPODES*; as the clio, cleodore, and hyalea.

CLASS III. *THE GASTEROPODES;* as the slug, snail, and limpet.

CLASS IV. *THE ACÉPHALES,* (without heads); as the oyster, and muscle.

CLASS V. *THE BRACHIOPODES;* as the lingula, and terebratula.

CLASS IV. *THE CIRRHOPODES;* as the barnacle.

DIVISION III. ARTICULATED ANIMALS.

Four Classes.

CLASS I. *ANNÉLIDES, OR WORMS.*

Order I. The Tubicoles, forming a calcareous tube around them; as the scopula, sabella, and terebella.

ORDER II. THE DORSIBRANCHES, the limbs diffused over the body; as the néréïde and aphrodite.

ORDER III. THE ABRANCHES, (without limbs); as the earth-worm and leech.

CLASS II. THE CRUSTACEOUS.

Five orders, formed from the number, or position of their organs of motion.

ORDER I. THE DÉCAPODES; as the crab, lobster, and prawn.

ORDER II. THE STOMAPODES; as the squill.

ORDER III. THE AMPHIPODES; as the gammarus.

ORDER IV. THE ISOPODES; as the wood-louse.

ORDER V. THE BRANCHIOPODES; as the monocullus.

CLASS III. THE ARACHNIDES, OR SPIDER TRIBE.

Two orders, formed from respiration being effected by pulmonary cells; or by tracheæ, or openings in the skin.

ORDER I. THE PULMONAIRES; as the spider, tarantula, and scorpion.

ORDER II. THE TRACHÉENNES; as the phalangium, and mite.

CLASS IV. INSECTS.

Twelve orders, derived principally from the number of their feet and wings.

ORDER I. THE MYRIAPODES, having numerous feet; as the iulus, centipes.

ORDER II. THE THYSANOURES, having appendages to their tails; as the lepisma, or wood-fish, and podura.

ORDER III. THE PARASITES; as the louse.

ORDER IV. THE SUCEURS; as the flea.

ORDER V. The COLÉOPTÈRES, having cased wings; as the carabus, beetle, lady-bird, glow-worm.

ORDER VI. THE ORTHOPTÈRES, having straight wings; as the earwig, locust, grasshopper, and mole cricket.

ORDER VII. THE HÉMIPTÈRES, or half-winged; as the bug, the water-scorpion, lantern-fly, aphis, and cochineal.

ORDER VIII. THE NÉUROPTÈRES, having net-work wings; as the dragon-fly, and ephemera.

ORDER IX. THE HYMENOPTÈRES, having membranous wings; as the ichneumon, ant, sphex, wasp, and bee.

ORDER X. THE LEPIDOPTÈRES, having scaly wings; as the butterfly and moth.

ORDER XI. THE RHIPIPTÈRES, having fan-like wings; as the xenos, and stylops.

ORDER XII. THE DIPTÈRES, having two wings; as the gnat, and house-fly.

DIVISION IV. ZOOPHYTES. Four Classes.

CLASS I. THE ECHYNODERMES; spined skin; as the star-fish, and echinus.

CLASS II. THE INTESTINAUX, or intestinal animals; as the tænia, ascaris, and hydatid.

CLASS III. THE ACALÈPHES, or sea-nettle; as the sea-anemony, and medusa.

CLASS IV. THE POLYPES, or many-feeted; as the hydra, corallinè, and sponge.

CLASS IV. THE INFUSOIRES, found in animal and vegetable infusions; as the wheel animal, and proteus.

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THE END.

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